

## Effect Of Playing Position On Anaerobic Power And Related Physical Fitness Variables Of Female Field Hockey Players

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### ABSTRACT

**Background:** Field hockey is a high-intensity intermittent game, in which various playing positions differ as per required skills and game demand. The present study aims to determine the effect of playing position on the anaerobic power profile and related physical fitness variables of trained female field hockey players. **Methods:** Fifty-five [forward (FD, n=20), midfielder (MD, n=20), and defender (DF, n=15)] trained female hockey players were selected. Physical fitness variables [Anaerobic power (peak power=PP, average power=AP, minimum power=MP); back strength (BS), and endurance capacity ( $\dot{V}O_{2max}$ )], blood lactate ([La-]) and heart rate (HR) response were analyzed using standard protocol. **Results:** Midfielders (MD) have higher anaerobic power profiles [PP: FD=10.85%, DF=6.89%; AP: FD=7.31%, DF=2.42%; and MP: FD=2.85%, DF=11.32%] in comparison to FD and DF. Whereas, DF has higher BS (FD=10.18%, MD=9.5%); FD has higher  $\dot{V}O_{2max}$  (MD= 2.59%, DF=7.38%); and MD has higher [La-]<sub>resting</sub> (FD=9%, DF= 21.11%). The FD/DF have a higher [La-]<sub>peak</sub> (MD=7.05%) and FD has a higher HR<sub>peak</sub> (MD=2.62%, and DF=0.67%). BS has a significant ( $p<0.001$ ) positive correlation with anaerobic power. **Conclusion:** Forward (FD) players have an advantage in terms of higher endurance capacity ( $\dot{V}O_{2max}$ ). Midfielders (MD) were counted as an advantage in terms of [La-]<sub>resting</sub> and anaerobic explosive power output. Whereas, the defenders (DF) were advantageous for higher muscular strength improvement. The back strength, [La-]<sub>peak</sub>, and  $\dot{V}O_{2max}$  could all be statistically predicted using anaerobic power indices.

**Keywords:** Anaerobic power output; playing position effect; field-hockey players; Wingate anaerobic bike.

### INTRODUCTION

Hockey is an intermittent team sport that requires intense bursts of high-intensity work phase activity and depends on both anaerobic and aerobic metabo-

lism (Calò et al.,2009; Cunniffe et al.,2021). In hockey, there are four main positional groups: forwards, midfielders, defenders, and goalkeepers. Each posi-

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tion is special in terms of playing demand and acquired skills. These roles can frequently change extremely fast, followed by a swift change back (Dewar et al.,2021).

A competitive hockey match requires players to sprint, stroll, jog, run, and change directions, hitting, passing, etc. Attack and defense actions need a substantial quantity of anaerobic and aerobic fitness, as well as the capability and strength to finish their tasks. It is a physically demanding sport where players must respond to opposing players' actions with maximum power (Manna et al.,2010). The overall match demands cannot be determined by using data from the playing halves because such fluctuations are too slight to be detected during a real match-play (Dewar et al., 2021). Wingate Anaerobic Test is a laboratory-based cycle ergometer test that gives the values for maximum, average, and minimum power output (both absolute and relative measures), fatigue index, and anaerobic fatigue (Barfield et al.,2002; Hoffman et al.,2000; Potteiger et al.,2010). Throughout the entire hockey match, the back and abdominal muscles experience the most strain as the players must bend forward to the ground to maximize skillful groundwork and cover a broader range (Koley et al.,2012). Blood lactate concentration ([La-]) levels essentially function as an indirect measure for metabolic events and give an insight into muscle exhaustion. The rate of lactate production which surpasses the lactate removal rate, is determined by several factors. The physiological mechanism for why endurance training attenuates blood lactate accumulation during

exercise remains to be clearly defined. One explanation suggests that aerobic training increases mitochondrial density within the muscle (Baechle et al.,2008; Sahlin et al.,1976; Stevens et al.,1983; Steeves et al.,2019). Improvement in the mitochondrial enzymatic activity allows for greater ATP production through the oxidative system and causes less lactate or  $H^+$  formation for a given workload. An athlete with higher oxidative potential would therefore need less recovery time (Steeves et al.,2019;Manna et al.,2010).

The present study aimed to observe the effect of playing position on anaerobic power profile, endurance capacity, and back strength of trained female field hockey players which is conducted to find out how senior top Indian female hockey players' training affected female hockey players.

## **MATERIALS AND METHODS**

### **Subjects**

A total of 55 young trained female field hockey players coming from three different playing positions i.e., forwards (FD=20), midfielders (MD=20), and defenders (DF=15), were recruited as subjects for the present cross-sectional study. All the study subjects are regular residential trainees of Sports Authority of India, Netaji Subhas National Institute of Sports (NSNIS), Patiala, and belong to the National Centre of Excellence (NCoE) scheme. All participants have a minimum of 4 years of formal training history. Players were considered to be homogeneous as they were residential players and came from almost the same socio-economic background thus the dietary habits and training environment were

almost the same. A proper clinical examination was done by the sports physician before commencing the study. The ethical guidelines of the Helsinki Declaration were maintained throughout the study protocol and written consent was also obtained.

### Training regimen

The training regime of the female field hockey players was the same irrespective of their playing position for 4 hours every day except for Sundays. Daily training was divided into two sessions (morning and evening) with 2 hours each session. The morning session consisted of physical conditioning and body weight training while the evening session consisted of skill and tactics training. Strength, Plyometric, Aerobic Endurance, and Speed and agility training protocols were added to their training regimen for both the morning and evening sessions. Warm-up and cool-down sessions were also included along with flexibility training. (Sarkar et al.,2020; Sarkar et al.,2019)

### General physical measures

Height and Body weight were measured using the SECA Stadiometer (model 787, Hamburg, Germany) with standard procedure. Muscular strength was measured using the back strength dynamometer (Takei, 5402, Takei Physical Fitness test) following the standard procedures (Sarkar et al.,2019). A polar heart rate monitor (polar RS800CX, Polar Electro OY, Kempele, Finland) was used to measure the  $HR_{resting}$  and  $HR_{peak}$  of female hockey players. Resting values of both HR and [La-] were

taken at rest with a minimum of 15min quiet sitting posture (pre-exercise). While peak/ max values of HR and [La-] were measured immediately post-exercise. All variables were measured one time (cross-sectional study) and collected under similar environmental conditions.

### Measurement of blood lactate concentration

Resting blood lactate concentration ( $[La-]_{resting}$ ) and peak blood lactate concentration ( $[La-]_{peak}$ ) were measured by a portable lactate analyzer (lactate Scout+, Senslab GmbH Bautzner Strasse 67 D-04347 Leipzig Germany) with the lactate dehydrogenase method. The basis of this method is the 37°C temperature-dependent conversion of pyruvate to lactate, which takes 120 seconds to complete. The strip containing pyruvate and NADH is mixed with a determined amount of serum that has been diluted three times. By employing reflectance spectroscopy to evaluate the rate at which NADH disappears at 340 nm with a calibration curve created with lactate dehydrogenase calibrators, lactate dehydrogenase activity is determined (Stevens et al.,1983).

### Measurement of maximal oxygen consumption ( $\dot{V}O_{2max}$ )

The Yo-Yo Intermittent Recovery Test Level 1 (YYIRT1) was used to measure the  $\dot{V}O_{2max}$ . The test involves running a distance of 20m with an additional 5m distance for recovery purposes. Over the distance of the 20-meter sprint, athletes had to keep their pace while the "beep" sound increased in frequency. Using the standard Yo-Yo test recording

chart, the final estimation of  $\dot{V}O_{2max}$  was derived from the shuttle results (Sarkar et al.,2020).

### Estimation of anaerobic power output

The Anaerobic Power output was predicted by using the 30-sec Wingate Anaerobic Power Test. The Wingate is a maximal exercise test of 30 seconds done on a mechanically braked bicycle ergometer (Monark 894E Peak Bike Ergometer). A 10-minute warm-up was done before the test and then the ergometer seat was adjusted as per the player's height and the test administrator added brake weight i.e., 7.5% of the total body weight. The administrator should lift the basket away from the flywheel after the weight has been added so the participant can cycle at 60 rpm without encountering any resistance. The administrator counts down "3-2-1- GO", the brake weight is lowered and the player must accelerate maximally and try to maintain the maximal speed for 30 seconds. Absolute and relative (calculated divided by body weight) power output for peak power (PP), average power (AP), and minimum power (MP), were measured through the Wingate test along with calculating the time to power drop (tPP),

and power drop (PD) (Castañeda-Babarro,2021).

### Statistical analysis

The research data was analyzed using the Statistical Package for the Social Sciences (SPSS), version 18.0 (SPSS Inc., Chicago, IL, USA). All values were expressed using the group mean  $\pm$  standard deviation (SD). One sample Kolmogorov-Smirnov test and histogram were performed to check the normality, and frequency distribution of the data set. Differences between the groups were analyzed using a one-way analysis of variance (ANOVA) and the confidence interval for the significance was set at 95% ( $P < 0.05$ ). For performance analysis, the significant predictors were identified using a linear regression model ( $R^2$  linear). Pearson's correlation matrix was also done to show the correlation statistics.

## RESULTS

Table 1 depicts the general anthropometric variables of female hockey players from various playing positions. None of the variables including age, height, and body weight have shown to be significantly different among

**Table 1: Comparison of general anthropometric variables among various playing positions of trained female field hockey players.**

Variables	Forward (n=20)	Midfielder (n=20)	Defender (n=15)	Combined (n=55)	F value (Sig.)
Age (year)	19.65 $\pm$ 1.78	19.65 $\pm$ 2.18	20.66 $\pm$ 2.58	19.93 $\pm$ 2.18	0.797(0.498ns)
Height (cm)	155.75 $\pm$ 6.15	156.65 $\pm$ 3.03	158.13 $\pm$ 5.17	156.73 $\pm$ 4.74	0.668(0.573ns)
Weight (kg)	50.00 $\pm$ 5.43	52.25 $\pm$ 5.06	53.20 $\pm$ 5.99	51.69 $\pm$ 5.52	1.080(0.361ns)

*Values are in Mean $\pm$ SD, ns= non-significant., Sig.= level of significance.*

**Table 2: Comparison of Anaerobic power variables among various playing positions of trained female field hockey players.**

Variables	Forward (n=20)	Midfielder (n=20)	Defender (n=15)	Combined (n=55)	F value (Sig.)
PP(watt)	414.68±68.37	459.70±75.63	430.04±76.3	435.24±74.51	1.271(0.288ns)
RPP (watt/kg)	8.30±1.08	8.82±1.33	8.05±0.81	8.42±1.14	1.439(0.236ns)
tPP (ms)	5.23±1.99	5.25±2.44	6.04±2.71	5.46±2.35	0.419(0.740ns)
AP (watt)	321.99±49.76	345.54±41.07	337.36±43.75	334.75±45.46	0.924(0.432ns)
RAP (watt/kg)	6.44±0.75	6.64±0.71	6.36±0.43	6.49±0.66	0.562(0.641ns)
MP (watt)	201.62±63.97	207.38±39.97	186.29±67.41	192.90±66.09	0.185(0.906ns)
RMP (watt/kg)	4.02±1.23	4.01±0.89	3.55±1.32	3.75±1.31	0.443(0.723ns)
PD (watt)	213.06±64.65	270.32±98.25	243.75±97.42	242.25±89.08	1.408(0.245ns)
RPD (watt/kg)	4.28±1.32	5.18±1.88	4.50±1.58	4.67±1.63	1.104(0.351ns)

Values are in Mean±SD, ns= non-significant., PP= peak power, RPP= relative peak power, tPP= time to peak power, AP= average power, RAP= relative average power, MP= minimum power, RMP= relative minimum power, PD= power drop, RPD= relative power drop, Sig.= level of significance.

various playing position groups. Which depicts the age-matched nature of the positional groups. Although the defenders were found to be slightly taller and heavier (in a statistically non-significant manner) individuals if compared among positional groups.

Table 2 represents the comparison of the anaerobic power output of various playing positions of trained field hockey players. The table depicts that none of the variables from the anaerobic power profile have shown significance when compared among various playing positions. The midfielder position was identified to have the highest anaerobic power output (peak, average, and minimum power) in comparison to other positions. But in terms of time to peak power (tPP), the power drop (PD) was found to be higher among defenders and midfielders respectively.

Table 3 depicts the comparison of

muscular strength, heart rate, [La-], and  $\dot{V}O_{2max}$  of various playing positions of female field hockey players. The table reveals that there is no significant difference found in muscular strength, heart rate, [La-], and  $\dot{V}O_{2max}$  when compared among various playing positions of female field hockey players.

Table 4 depicts Pearson's correlation matrix of anaerobic power variables with some selected fitness parameters. Back strength (BS) was found to be positively and significantly ( $p<0.001$ ) correlated with anaerobic power (both peak and average power). Whereas power drop was found to be positively and significantly ( $p<0.01$ ) correlated with the BS. Other variables ([La-]<sub>peak</sub> and  $\dot{V}O_{2max}$ ) were found to be positively correlated with anaerobic power indices but in a statistically insignificant manner.

Table 5 depicts the regression

**Table 3: Comparison of muscular strength, Heart rate, Blood lactate, Endurance Capacity**

Variables	Forward (n=20)	Midfielder (n=20)	Defender (n=15)	Combined (n=55)	F value (Sig.)
BS (kg)	76.75±9.60	77.23±7.93	84.57±13.20	79.05±10.55	1.949(0.126ns)
[LA-] <sub>resting</sub> (mmol/L)	3.00±0.96	3.27±0.91	2.70±1.15	3.01±1.00	0.914(0.437ns)
[LA-] <sub>peak</sub> (mmol/L)	18.67±4.05	17.44±4.37	18.67±3.27	18.22±4.06	0.388(0.762ns)
HR <sub>resting</sub> (bpm)	72.55±7.63	75.15±8.44	69.33±7.77	72.62±8.16	1.485(0.233ns)
HR <sub>peak</sub> (bpm)	189.40±8.26	184.55±8.83	188.13±8.58	187.29±29.00	1.123(0.343ns)
$\dot{V}O_2$ max (ml/kg/min)	53.07±6.18	51.73±5.16	49.42±3.95	51.59±5.38	1.346(0.263ns)

Values are in Mean±SD, ns= non-significant., BS= back strength, [LA-]<sub>resting</sub> = resting blood lactate concentration, [LA-]<sub>peak</sub> = peak blood lactate concentration, HR<sub>resting</sub> = resting heart rate, HR<sub>peak</sub> = peak heart rate,  $\dot{V}O_2$ max= maximal oxygen consumption, bpm= beats per minute, sig= level of significance

**Table 4: Pearson's correlation matrix among anaerobic power variables and back strength, peak lactate conc., and endurance capacity.**

Variables	Back Strength	[La-] <sub>peak</sub>	$\dot{V}O_2$ max
PP	<0.001***	0.216	0.655
AP	<0.001***	0.366	0.893
PD	0.001**	0.187	0.460

\*\*\*= $p < 0.001$ , \*\*= $p < 0.01$ , PP= peak power, AP= average power, PD= power drop, [La-]<sub>peak</sub>= peak blood lactate,  $\dot{V}O_2$ max= maximal oxygen consumption.

**Table 5: Regression equations predicting back strength, endurance capacity, and peak blood lactate concentration.**

Dependent variable	Multiple regression equation	R	R <sup>2</sup>	SEE
Back Strength	-(0.089)PP+(0.193)AP+(0.054)PD+40.398	0.552	0.305	9.05492
[La-] <sub>peak</sub>	-(0.017)PP+(0.019)AP-(0.003)PD+20.238	0.201	0.041	4.08818
$\dot{V}O_2$ max	(0.021)PP-(0.033)AP+(0.003)PD+52.751	0.132	0.017	5.49039

R= correlation coefficient, SEE= standard error of the estimate, PP= peak power, AP= average power, PD= power drop, [La-]<sub>peak</sub> = peak blood lactate concentration,  $\dot{V}O_2$ max= maximal oxygen consumption.

equations predicting the back strength, peak blood lactate ( $[La-]_{peak}$ ), and maximal oxygen consumption ( $\dot{V}O_{2max}$ ) by using peak power (PP), average power (AP), and power drop (PD) as the dependent variable here. The anaerobic power variables were able to predict the back strength ( $F = 7.457$ ,  $p < .001$ ;  $t = 4.036$   $p < .001$ );  $[La-]_{peak}$  ( $F = 0.718$ ,  $p = 0.546$ ;  $t = 4.478$   $p < .001$ ) and  $\dot{V}O_{2max}$  ( $F = 0.299$ ,  $p = 0.826$ ;  $t = 8.696$   $p < .001$ ).

## DISCUSSION

Hockey is a skillful high-intensity sport that needs various physical demands i.e., speed, agility, endurance capacity, and anaerobic power output etc. skills to optimize performance. The present study athletes consist of three different playing positions i.e., forward, midfielder, and defender. The present study depicts that those players who play forward (FD) have an advantage because of their greater  $\dot{V}O_{2max}$  endurance capability. The advantage of  $[La-]_{resting}$  and anaerobic explosive power output was accounted for by midfielders (MD). Defenders (DF) have an advantage when it comes to increasing their muscle strength.

In the present study, MD was found to have more anaerobic power output (except time to time at peak power) than other playing positions (peak power difference FD=10.85%, DF=6.89%; average power difference FD=7.31%, DF=2.42%; and minimum power difference FD=2.85%, DF=11.32%) but all the difference was found to be statistically non-significant. The present study result corroborates with the previous studies (Lemmink et al.,2006; Manna et al.,2010). The result showed that they are

more dependent on anaerobic metabolism because as per the game demand, midfielders have to play in both attacking and defending modes. Hence the players in the midfielder position need more explosive energy bursts to support the high-intensity nature of the playing position which might be fulfilled by the high anaerobic power capacity. According to Koen Lemmink et al. (2006), hockey players who showed the highest fatigue during cycling also had the most peak power output, and maximum power output possibly due to a large percentage of fast-twitch fibers (Kraemer et al.,1995; Potteiger et al.,2010). Under comprehensive training, field hockey players have also routinely performed exercises that optimize muscle hypertrophy and cordially enhance their lower limbs' strength to produce peak muscular power (Potteiger et al.,2010). Kraemer et al., (1995) have also reported that extended endurance training could also prevent generating anaerobic power and force. Relative anaerobic power output was found to be higher in midfielders. In this study, midfielders gave their maximum power output with a minimum  $[La-]$  value. Sarkar et al. (2019) reported that soccer players were shown to have an elevated relative anaerobic power output, which could suggest that they have a higher lactatetolerance than their hockey counterparts. It means it can be demonstrated that midfielders can produce more power with minimum energy.

The anaerobic system plays a crucial role as the game demands high-intensity sprinting which requires explosive short-duration energy bursts which must correspond with higher  $[La-]$  accumula-

tion. The [La-] can reach levels above 20 mmol/L during periods of extreme exertion. Endurance-trained individuals were supposed to experience a reduction in [La-] production as well as a possible faster rate of [La-] clearance during recovery from strenuous exercise because of increased oxidative power in the trained condition (Aziz et al., 2000; Bishop et al., 1993; McGrail et al., 1978; Steeves et al., 2019). Field hockey players' performance could be optimized depending on the lactate tolerance and removal capacity (Sarkar et al., 2019). In the present study, FD and DF were found to have more peak lactate than other playing positions (peak lactate difference MD=7.05%). According to MacDougall et al. (2011), maximal short-term power production and glycolytic and oxidative enzyme activity can both be increased with shorter but intensive sprint training (about 90% HR<sub>peak</sub>) (Allisse et al., 2023). In the present study, forwards and defenders were found to have the highest [La-] in comparison to midfielders although the difference was not statistically significant. However, the present study shows that [La-]<sub>peak</sub> has an insignificant positive correlation with anaerobic power i.e., PP (p=0.216), AP (p=0.366), and PD (p=0.187). The regression analysis showed that anaerobic power variables revealed insignificantly (F = 0.718, p = 0.546) predict the [La-]<sub>peak</sub> [prediction equation: [La-]<sub>peak</sub> = -(0.017) PP + (0.019) AP - (0.003) PD + 20.238 with R=0.201, R<sup>2</sup>=0.041 and SEE=4.08818.

In the present study, hockey DF was found to have more BS than other playing positions (BS difference FD=10.18%, DF=9.5%). Midfielders were shown to

have strong muscles, which may aid in their ability to sprint in the right direction and maintain body balance (Sarkar et al., 2019). Hoffman et al. (2007) demonstrated that the reason for greater muscular strength is a greater protein mass content and may have undergone muscle hypertrophy because of their non-significantly increased muscular isometric strength. Sarkar et al. (2019) also demonstrated that rugby players had to sprint momentum, body balance, and sensory-motor with training adaptation because of proper muscular hypertrophy among these playing positions. Earlier research by Roy et al. (2001) revealed a high correlation between back strength and other anthropometric factors across several groups. However, the present study shows that BS has a significant (p<0.001) positive correlation with anaerobic power i.e., PP (p<0.001), AP (p<0.001), and PD (p<0.01). The regression analysis depicted that anaerobic power variables can significantly (F = 7.457, p<0.001) predict the BS [prediction equation: BS = -(0.089) PP + (0.193) AP + (0.054) PD + 40.398] with R=0.552, R<sup>2</sup>=0.305, and SEE=9.05492.

In field hockey, aerobic capacity plays a significant role and influences both technical performance and tactical decisions (Manna et al., 2010). As shown in the results, Forward players of the present study have more  $\dot{V}O_{2max}$  rather than other positions ( $\dot{V}O_{2max}$  difference MD=2.59%, DF=7.38%) but it also showed non-significance. The reason may be that they are responsible for scoring and assisting goals. Forward players cover more distance in the hockey field than in other positions. The muscle

capillary and mitochondrial density increases, or the peripheral factor gradient, may be the cause of the midfielder hockey players' improved  $\dot{V}O_{2max}$  (Smith et al., 2013). The increase in left ventricular (LV) muscle mass, LV contractility during exercise, and stroke volume which may be the likely cause of the incline in  $\dot{V}O_{2max}$  raised the cardiac output in the end (Sarkar et al., 2019). Additionally, Bassett and Howley (2000) noted an increase in  $\dot{V}O_{2max}$ , which may have resulted from a rise in cardiac output brought on by the over-perfusion of the muscles during exercise. According to Green et al. (2006), it is also conceivable that having a high level of aerobic fitness extends the duration before fatigue and improves recovery in between changes throughout the match. The outcome would be more participation of players on the field, both attacking and defensive end. More scoring possibilities could arise from this and stronger defensive performance, which would reduce the opposition's opportunity to score collectively. These results confirm earlier studies that it is essential to have a well-developed aerobic energy pathway for achievement in the top tier (Cox et al., 1995) and additionally support at this level, the significance of off-ice aerobic conditioning of recreation. However, the present study shows that  $\dot{V}O_{2max}$  has a non-significant positive correlation with anaerobic power i.e., PP ( $p=0.655$ ), AP ( $p=0.893$ ), and PD ( $p=0.460$ ). The regression analysis showed that anaerobic power variables can insignificantly ( $F=0.299$ ,  $p=0.826$ ) predict the  $\dot{V}O_{2max}$  [prediction equation:  $\dot{V}O_{2max} = (0.021)PP - (0.033)AP + (0.003)PD + 52.751$ ] with  $R=0.132$ ,  $R^2=0.017$

and  $SEE=5.49039$ .

## CONCLUSIONS

In the present study, female hockey players who play forward (FD) were found to be less prone to fatigue with more endurance capacity as they have higher  $\dot{V}O_{2max}$  values than MD (2.59%) and DF (7.38%). The advantage of [La-]resting (FD=9%, DF=21%), anaerobic explosive power output [PP: FD=10.85%, DF=6.89%; AP: FD=7.31%, DF=2.42%; and MP: FD=2.85%, DF=11.32%], were considered midfielders (MD). Defenders (DF) have a back muscle strength advantage (FD=10.18%, DF=9.5%). Lower limb muscular explosive strength depends or/and can influence the back muscle strength as the BS has a significant positive correlation with anaerobic power indices. Whereas, the anaerobic power indices were found significant to predict the back strength, [La-]<sup>peak</sup>, and  $\dot{V}O_{2max}$ . Hockey players, coaches, and strength and conditioning personnel may find the current study data very helpful in developing a systematic conditioning training program that meets positional demands and reduces the possibility of overtraining and injury during a training session. However, more research on the study of positional effect needs to be done especially on a broader athletic population to standardize the positional demand.

## Conflict of Interest

All authors have agreed to publish the present article and declare no conflict of interest.

## Acknowledgments

The authors express their sincere

gratitude to the players for their valuable participation in the present study. The authors are also grateful to Netaji Subhas National Institute of Sports, Patiala for giving all kinds of support and facilities for the completion of the present study.

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