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ORIGINAL ARTICLE

Morphological, Physiological and Biochemical Characteristics of Indian Field Hockey Players of Selected Age Groups

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Abstract: *Objectives:* The morphological, physiological and biochemical variables at various stages of growth and development provide valuable information for selection of players of different age groups. *Methods:* One hundred and twenty (N= 120) field hockey players volunteered for this study. The players were divided equally (n=30) into 4 groups: (i) under 16 years (U16), (ii) under 19 years (U19), (iii) under 23 years (U23) and (iv) senior (SR). Selected morphological, physiological and biochemical variables were measured in the laboratory. *Results*: Results showed significantly higher (P<0.05) body mass, height and LBM in the U23 and senior players when compared to U16 and U19 players. However, significantly (P<0.05) lower percent body fat was noted in U16 and U19 players as compared to U23 and senior players [Body fat (%): (U16- 18.7 ± 2.0, U19-15.5 ± 1.4, U23-13.9 ± 1.2, SR-12.0 ± 0.5]. It was observed that in U19 players possess significantly higher (P<0.05) VO_{2max} than the other age group players [VO_{2max} (ml kg^{-1} min^{-1}): U16- 54.6 ± 2.8, U19-57.0 ± 3.9, U23-56.0 ± 3.7, SR-54.1 ± 4.0]. Further, significantly higher (P<0.05) anaerobic power, strength, haemoglobin (Hb), serum urea and uric acid was noted in the U23 and senior players when compared to U16 and U19 players. The values of total cholesterol (TC), triglyceride (TG), high density lipoprotein cholesterol (HDL-C), and low density lipoprotein cholesterol (LDL-C) were significantly higher (P<0.05) in the upper age group (U23 and senior) players when compared to junior (U16 and U19) players. *Conclusion*: The unique profile of age related changes should be taken into consideration while selecting the players in teams.
Key words: body fat, VO_{2max}, anaerobic power, strength, lipid profile

Introduction

Physique and body composition play important role in field hockey [1-2]. Since lots of movements and skills are involved in playing field hockey therefore, a high level of physical demand is required for match play [1, 3]. As the players have to cover a big area in the ground during attack and defense therefore, the game demands for aerobic as well as anaerobic fitness [1, 4]. A high number of accelerations and decelerations, associated with the large number of changes in direction of play create an additional load to the muscles involved as in field hockey, those players better suited to cope with the demands of the game reach the elite level [1, 4]. Moreover, power and strength has great impact over the game, which is required during sprinting and in execution of various skills with the ball [1, 3].

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During aerobic exercise the demand of oxygen increases at the working muscle, so an optimum level of hemoglobin is required to perform at the highest level with high intensity [5]. The serum level of urea and uric acid are used for assessment of training related stress [6]. Lipids have important beneficial biological functions that include the use of triglycerides, for energy production or as stored fat in adipose tissue and use of cholesterol as a component, in conjunction with phospholipids of cellular membranes or in the synthesis of steroid hormones [7]. Regular monitoring of this health related variables of field hockey players can provide valuable information about their health, metabolic and cardiovascular status.

This study has been focused on the field hockey players as the game is most popular and played through out the world. Some of the earlier studies concentrated on the maximum oxygen capacity and body composition of hockey players [8-10]. However, the morphological, physiological and biochemical characteristics of Indian field hockey players have not studied before on different competition age groups. Regular monitoring of selected morphological, physiological and biochemical variables at various stages of growth and development may provide valuable information to the coaches for selection of players of different age groups. Moreover, this information at the selection level provides the scientists and the coaches a basic level to observe the improvement of the players during a training session. On the basis of the above the present study has been designed to find out age related variations in the morphological, physiological and biochemical characteristics of Indian field hockey players.

Material and Methods

Subjects and Testing: One hundred and twenty (N=120) Indian male, regularly playing competitive field hockey, volunteered for the present study. They were selected from the training camps at Sports Authority of India. The players were equally divided (n=30) into 4 groups: (i) under 16 years (U16, age: 14.00-15.99 yr, playing for last 2-3 years), (ii) under 19 years (U19, age: 16.00-18.99 yr, playing for last 4-7 years), (iii) under 23 years (U23, age: 19.00-22.99 yr, playing for last 8-11 years) and (iv) senior (SR, age: 23.00-30.00 yr, playing for last 12-17 years). The selected morphological, physiological and biochemical parameters were measured in the laboratory. Each test was scheduled at the same time of day (± 1 hour) in order to minimize the effect of diurnal variation. All the experiments were performed at 25 ± 1^{o}C, with relative humidity of 60–65%. The subjects were informed about the possible complications of the study and gave their consent. The study was conducted at Sports Authority of India and was approved by the Human Ethical Committee of the Institute. The subjects who were not participated in regular training program were excluded from this study.

Measurement of Morphological Variables: Body mass was measured with the accurately calibrated electronic scale (Seca Alpha 770, UK) to the nearest 0.1 kg [11]. Stature (height) was measured with stadiometer (Seca 220, UK) recorded to the nearest 0.5 cm [11]. Body density was estimated from the sum of the skin-fold sites

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based on the standard procedure [12], and estimated percentage body fat was calculated using standard equation [13]. Lean body mass (LBM) was calculated by subtracting fat mass from total body mass.

Measurement of Physiological Variables: Treadmill (Jaeger, LE 500, Germany) tests were performed to determine the cardiovascular status of the players during maximal exercise. The maximum oxygen consumption (VO_{2max}) was measured following standard methodology [14]. The subject was asked to run on the treadmill at a speed of 6 km/h for 2 min. thereafter, the workload was increased by 2 km/h for every 2 min. until volitional exhaustion. Expired gases were sampled and measured from a mixing chamber using computerized respiratory gas analyzer (Oxycon Champion, Jaeger, Germany). Heart rate responses during exercise and recovery were noted using sports testers (Polar). Anaerobic power was measured using cycle ergo-meter (Jaeger, LE 900, Germany) following the Wingate anaerobic test [15]. Strength of the grip and back was measured with the help of dynamometers following standard procedure [11].

Measurement of Biochemical Variables: A 5 ml of venous blood was drawn from an antecubital vein after a 12-hours fast and 24 hours after the last bout of exercise for the subsequent determination of selected biochemical parameters. The biochemical parameters were measured using standard methodology. All the reagents were supplied from Boehringer Mannhein, USA. Haemoglobin was measured using Cyanmethaemoglobin method [16]. Serum urea [17] and uric acid [18] were determined calorimetrically. Serum triglycerides [19], serum total cholesterol (TC) [20] and high-density lipoprotein cholesterol (HDL-C) [20] were determined by enzymatic method. Low-density lipoprotein cholesterol (LDL-C) was indirectly assessed following standard equation [21].

Statistical Analysis: All the values of morphological, physiological and biochemical parameters were expressed as mean and standard deviation. Analysis of Variance (ANOVA) with repeated measures followed by multiple comparison tests was performed, to find out the significant difference in selected morphological, physiological and biochemical parameters among the selected age categories. Correlation coefficient was performed among the morphological, physiological and biochemical parameters. In each case the significant level was chosen at 0.05 levels. Accordingly, a statistical software package (SPSS) was used.

Results

Morphological characteristics of Indian field hockey players of four age groups: A significant ($P<0.05$) reduction in percent body fat was observed from lower age category to higher age category players. The lower percent body fat was noted in the senior age-group players when compared to U16, U19 and U23 age group. However, significant increase ($P<0.05$) in LBM, body mass, and stature was reported from lower age category to higher age category players. The higher LBM, body mass, and stature were noted in the U23 and senior age-group players when compared to U16 and U19 age group. No significant change in LBM, body mass, and stature was reported between U23 and senior age group players.

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Table-1: Morphological variables of Indian field hockey players of selected age groups				
Parameters	Age group			
	U16	U19	U23	SR
Height (cm)	163.5 ± 2.4	170.3* ± 3.4	172.7$^{*\#}$ ± 3.3	173.3$^{*\#}$ ± 3.2
Body mass (kg)	53.9 ± 3.9	60.7* ± 3.7	63.8$^{*\#}$ ± 3.4	64.9$^{*\#}$ ± 4.4
Body fat (%)	18.7 ± 2.0	15.5* ± 1.4	13.9$^{*\#}$ ± 1.2	12.0$^{*\#¥}$ ± 0.5
LBM (kg)	40.0 ± 4.4	46.2* ± 4.1	50.0$^{*\#}$ ± 4.9	52.1$^{*\#}$ ± 3.6
Data presented as mean ± SD; n=30; Computed using alpha = 0.05; * when compared to U16, # when compared to U19, ¥ when compared to U23, U16= under 16 yrs, U19= under 19 yrs, U23= under 23 yrs, SR= senior age groups; LBM= lean body mass.				

Physiological characteristics of Indian field hockey players of four age groups: In the present study VO_{2max} values of field hockey players exhibit variation in different age categories, and it was seen that during adolescence (under 19 yrs) VO_{2max} elevated ($P<0.05$) and then declined ($P<0.05$) further in the senior age group players. A significantly higher ($P<0.05$) relative VO_{2max} value was noted in U19 age group players when compared to U16, U23 and senior age group players. In addition, significantly higher ($P<0.05$) HRmax and recovery heart rates were noted in U16 and U19 age group players when compared to U23 and senior age group players. The U23 and senior players showed significantly ($P<0.05$) higher anaerobic power when compared to U16 and U19 age group players. In addition, a significantly higher ($P<0.05$) back and grip (right and left hand) strength were noted in U23 and senior age group players when compared with that of the U16 and U19 age group players.

Table-2: Physiological variables of Indian field hockey players of selected age groups				
Parameters	Age group			
	U16	U19	U23	SR
VO_{2max} (ml kg^{-1} min^{-1})	54.6 ± 2.8	57.0* ± 3.9	56.0$^{\#}$ ± 3.7	54.1$^{\#}$ ± 4.0
HRmax (beats min^{-1})	195.3 ± 2.7	190.5* ± 2.5	185.5$^{*\#}$ ± 3.4	183.1$^{*\#}$ ± 4.6
RHR (beats min^{-1})	161.0 ± 3.6	152.5* ± 2.2	147.2$^{*\#}$ ± 2.1	145.9$^{*\#}$ ± 2.7
Anaerobic power (W kg^{-1})	8.2 ± 0.6	11.3* ± 0.9	13.8$^{*\#}$ ± 0.9	14.7$^{*\#}$ ± 1.1
BST (kg)	106.4 ± 4.0	113.3* ± 3.9	123.6$^{*\#}$ ± 3.5	125.0$^{*\#}$ ± 2.9
GSTR (kg)	28.0 ± 2.5	32.1* ± 1.5	35.2$^{*\#}$ ± 1.9	37.2$^{*\#}$ ± 0.9
GSTL (kg)	26.5 ± 1.8	28.4* ± 1.9	32.4$^{*\#}$ ± 1.7	33.6$^{*\#}$ ± 1.9
Data presented as mean ± SD; n=30; Computed using alpha = 0.05; * when compared to U16, # when compared to U19, ¥ when compared to U23, U16= under 16 yrs, U19= under 19 yrs, U23= under 23 yrs, SR= senior age groups; VO_{2max}= maximal aerobic capacity, HRmax= maximal heart rate, RHR= Recovery heart rate, BST= Back strength, GSTR= Grip strength of right hand, GSTL= Grip strength of left hand.				

Biochemical characteristics of Indian field hockey players of four age groups: In this study, a significant increase ($P<0.05$) in hemoglobin level was noted from lower age category to higher age category players. The highest hemoglobin level was noted in the senior age-group players when compared to U16, U19 and U23 age group players. In addition, a significant increase ($P<0.05$) in serum urea was noted from the lower age category to the higher age category players. The higher ($P<0.05$) serum urea level was observed in the senior age group players when compared to U16, U19 and U23 age group players.

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Further, the higher (P<0.05) serum uric acid level was observed in the U23 and senior age group players when compared to U16 and U19 age group players. A significant increase (P<0.05) in total cholesterol level was noted from lower age category to the higher age category players. The higher total cholesterol level was observed in the senior age group players when compared to U16, U19 and U23 age group players. In addition, a significant increase (P<0.05) in triglyceride level was noted from the lower age category to the higher age category players. The greater triglyceride level was observed in the senior age group players when compared to U16, U19 and U23 age group players. Similarly, a significant increase (P<0.05) in HDL-C level was noted from the lower age category to the higher age category players. Significantly higher HDL-C level was observed in the U23 and senior age group players when compared to U16 and U19 age group players. Further, a significantly higher (P<0.05) in LDL-C level was noted among the senior age group players when compared to U16, U19 and U23 age group players.

Table-3: Biochemical variables of Indian field hockey players of selected age groups

Parameters	Age group			
	U16	U19	U23	SR
Haemoglobin (gm dl^{-1})	13.6 ± 0.4	13.7 ± 0.6	$14.5^{*\#}$ ± 0.3	$14.9^{*\#¥}$ ± 0.3
Urea (mg dl^{-1})	24.9 ± 2.0	26.5^{*} ± 1.7	$30.5^{*\#}$ ± 2.6	$32.7^{*\#¥}$ ± 1.0
Uric acid (mg dl^{-1})	3.4 ± 0.3	3.6 ± 0.5	$4.7^{*\#}$ ± 0.3	$4.6^{*\#}$ ± 0.3
TC (mg dl^{-1})	154.7 ± 4.5	158.2^{*} ± 5.2	$163.4^{*\#}$ ± 5.7	$174.9^{*\#¥}$ ± 5.9
TG (mg dl^{-1})	90.5 ± 4.6	89.6 ± 5.9	$97.6^{*\#}$ ± 4.4	$103.6^{*\#¥}$ ± 5.1
HDL-C (mg dl^{-1})	33.5 ± 2.5	39.2* ± 3.1	40.9*# ± 3.1	$42.9^{*\#¥}$ ± 3.5
LDL-C (mg dl^{-1})	103.2 ± 5.9	101.1^{*} ± 4.9	$102.0^{*\#}$ ± 4.0	$109.3^{*\#¥}$ ± 4.9

Data presented as mean ± SD; n=30; Computed using alpha = 0.05; * when compared to U16, # when compared to U19, ¥ when compared to U23, U16= under 16 yrs, U19= under 19 yrs, U23= under 23 yrs, SR= senior age groups. TC= total cholesterol, TG= triglyceride, HDL-C= high density lipoprotein cholesterol, LDL-C= low density lipoprotein cholesterol.

Table 4: Correlation study among the morphological, physiological and biochemical parameters

Correlation	r value	Correlation	r value
Height vs Anaerobic power	0.34^{**}	Body fat vs Anaerobic power	$- 0.52^{**}$
Height vs Strength	0.61^{**}	Body fat vs Strength	$- 0.39^{**}$
Body mass vs Anaerobic power	0.28^{**}	VO_{2max} vs Haemoglobin	0.40^{****}
Body mass vs Strength	0.57^{**}	VO_{2max} vs HDL-C	0.3^{**}
Body mass vs Haemoglobin	0.41^{****}	Anaerobic power vs TC	0.2^{*}
Body mass vs HDL-C	0.2^{*}	Anaerobic power vs HDL-C	0.24^{**}
Body fat vs VO_{2max}	$- 0.37^{**}$	Strength vs Uric acid	0.2^{*}
		Strength vs HDL-C	0.3^{**}

N=120, Pearson's Correlation coefficient, the r values are significant when *P< 0.05, **P<0.01, ***P<0.001, ****P<0.000.

Correlation study among the morphological, physiological and biochemical parameters: In the present study, height showed significant positive (P<0.05) correlation with anaerobic power and strength. Similarly it has been seen that body mass had significant positive (P<0.05) correlation with anaerobic power, strength,

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haemoglobin and HDL-C. On the other hand, body fat showed significant negative ($P<0.05$) correlation with VO_{2max}, anaerobic power and strength. However, VO_{2max} showed significant positive ($P<0.05$) correlation with haemoglobin and HDL-C. Further, anaerobic power showed significant positive ($P<0.05$) correlation with total cholesterol and HDL-C. Strength showed significant positive ($P<0.05$) correlation with uric acid and HDL-C.

Discussion

Performance of the hockey players is affected by body composition and physique. A lean body is desirable for sports like field hockey [1-2]. In the present study, a significantly higher ($P<0.05$) height, body mass and LBM was noted from lower age category to higher age category field hockey players. This age group wise increase in height and body mass of the players might be due to growth and development of the players. In the present study, height showed significant positive ($P<0.05$) correlation with anaerobic power and strength. Similarly it has been seen that body mass had significant positive ($P<0.05$) correlation with anaerobic power, strength, haemoglobin and HDL-C. These changes might be due to growth and development of the players. In case of soccer, goalkeeper, forwards and defenders need higher stature compared to other playing positions. In case of field hockey height may not be as important as in case of soccer; however a standard height is required for all the playing positions [1-2]. The height and body mass of the hockey players may vary from one nation to another. In the present study the mean height and body mass of 173.3 ± 3.2 cm and 64.9 ± 4.4 kg have been noted in Indian senior hockey players. Earlier studies showed mean height of 171.7 ± 5.8 cm and body mass of 60.9 ± 4.8 kg for Indian senior hockey players [22]. However, the mean height and body mass of the Indian gold medal wining field hockey team at the Tokyo Olympics was 173 cm and 69.2 kg [23]. A recent study on Netherlands elite field hockey players reported mean height and body mass of 181 cm 75.9 kg [4]. Another study on German field hockey players showed height and body mass of 179.6 ± 6.3 cm and 73.9 ± 8.9 kg [24]. Height and body mass also varies with the ethnic and racial variation, for example the mean height and body mass of the Singapore National team was reported 170 cm 61.2 ± 5.6 kg [25]. It has been observed that the height and body mass of the Indian hockey players are less than that of the European counterparts, but similar to Singapore players. The lower height and body mass of the Indian hockey players might be one of the reasons for their limitations in the international competitions.

A low-body fat may improve athletic performance by improving the strength-to-weight ratio [26]. In the present study, a decrease ($P<0.05$) in body fat was noted from lower age group to higher age group players. The low body fat values in the senior players might be due to exposure to higher amount of aerobic endurance training compared with U16 and U19 age group players for a long time. These observations were supported by several studies; where decrease in body fat was noted from lower age category to higher age category players [1-2]. In field hockey frequent activities are part of the game, so excess boy fat may reduce the activity of the players [27].

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In the present study, body fat showed significant negative (P<0.05) correlation with VO_{2max}, anaerobic power and strength of the players. This indicated that increase in body fat might limit the aerobic and anaerobic performance of the players. In this study, Indian senior elite hockey players showed 12.0 ± 0.5 % of body fat. Recent studies on Netherlands elite male field hockey players reported to have body fat of 8.9 ± 1.12 % [4]. The body fat of the elite Indian hockey players was found higher than Netherlands elite male field hockey players. Excess body fat adds to the load without contributing to the body's force-producing capacity [26]. Therefore, increase in body fat may limit the performance of the players.

Aerobic capacity certainly plays an important role in modern field hockey and has a major influence on technical performance and tactical choices. The VO_{2max} values of Indian hockey players exhibit variation in different age categories, and it was seen that during adolescence (U19) aerobic capacity elevated and then declined further in the senior age group players. A significantly higher (P<0.05) relative VO_{2max} value was noted in U19 age groups players when compared with U16, U23 and senior age groups players. It was noted that the junior players (U16 age group) possess similar mean relative VO_{2max} values as the senior players. This lower mean relative VO_{2max} values in the senior players might be due to their higher body mass [23]. The observation of the present study is supported by the findings of many researchers, where relative VO_{2max} of the junior hockey players shows similar values with the seniors [1, 27]. The maximal oxygen uptake (VO_{2max}) is the best overall measure of aerobic power. In the present study the mean VO_{2max} value of 54.1 ± 4.0 ml kg^{-1} min^{-1} was noted in Indian senior hockey players. Previous study on Indian hockey players reported mean VO_{2max} value of 53.8 ± 9.1 ml $kg^{-1}min^{-1}$ [22]. A recent study on Canadian elite field hockey players reported to have a mean VO_{2max} value of 59.2 ml $kg^{-1}min^{-1}$ [1]. The VO_{2max} value of the Australian elite male hockey players showed a mean VO_{2max} value of 57.9 ± 3.6 ml $kg^{-1}min^{-1}$ [28]. Similarly, West Germany national players showed VO_{2max} value of 63.5 ml $kg^{-1}min^{-1}$; English players 62.2 ml $kg^{-1}min^{-1}$ and Spanish national hockey players showed VO_{2max} values of 59.7 ml $kg^{-1}min^{-1}$ [23]. The maximal aerobic capacity also varies with the ethnic and racial variation. It has been reported that reported the mean VO_{2max} value of 57.8 ± 6.2 ml $kg^{-1}min^{-1}$ in Singapore National hockey players [25]. Therefore, it appears that the VO_{2max} values of the elite Indian hockey players were less than those of their international counterparts, which may be one of the reasons for their limitations in the International arena. This indicates that during aerobic exercise the demand of oxygen increases at the working muscle, so an optimum level of hemoglobin is required to perform at the highest level with high intensity [29-30]. Therefore, the increase in VO_{2max} demands higher rate of supply of oxygen. Oxygen is transported to muscle primarily by hemoglobin (Hb), and it is suggested that hemoglobin mass and/or concentration is related to VO_{2max} [31-32]. In the present study, VO_{2max} showed significant positive (P<0.05) correlation with haemoglobin. In addition, a significant increase (P<0.05) in hemoglobin level was observed from lower age group to higher age group players. Similar findings have been reported by many researchers [31-32].

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Heart rate increases with an increase in work intensity and shows linear relationship with work rate [14]. The highest rate at which the heart can beat is the maximal heart rate (HRmax). Quick recovery from strenuous exercise is important in hockey which involves intermittent efforts interspersed with short rests [26]. A significant reduction ($P<0.05$) in HRmax and recovery heart rates were observed among the field hockey players from lower age group to higher age group. The largest influencing factor on the value of heart rate is the age of the individual [26]. The heart rate recovery curve is used as an excellent tool for tracking a person's progress during a training program [26]. The largest influencing factor on the value of HR_{max} is the age of the individual. On average HR_{max} decreases approximately 1 beat/min each year of advancing age [26]. Monitoring of heart rate can also be used to quantify the training in field hockey.

The game of hockey demands high anaerobic power as accelerate and decelerate quickly is the part of the game [33-35]. It is acceleration that is critical to hockey performance rather than maximal speed. A high anaerobic power is essential for such activities. The anaerobic power increased ($P<0.05$) from lower age group to higher age group players. Such increase might be related to the growth and development of the players [26]. Similar observations have been reported by many researchers [36-37]. In the present study, anaerobic power showed significant positive ($P<0.05$) correlation with total cholesterol and HDL-C. It indicated that these changes were due to growth and development of the players. In the senior elite Indian hockey players' anaerobic power of 14.7 ± 1.1 W kg^{-1}, was noted. In an analysis of a verity of state level Australian sportsmen, Withers et al found that hockey had relative anaerobic power of 15.2 W kg^{-1} [38]. The anaerobic power of Indian hockey players was found lower than that of their international counterparts. As anaerobic power was important for the game of hockey, Indian players should improve their power to achieve success in the International competitions.

On the other hand, strength is the central component of a field hockey training program [33-36]. Upper body strength allows players to shoot more powerfully and pass over a greater range of distances. In field hockey grip strength may have importance in handling the stick during execution of different skills in practice and competition. In the present study, strength increased ($P<0.05$) from lower age group to higher age group players. Such increase might be related to the growth and development of the players [26]. Similar observations have been reported by many researchers [36-37]. Strength showed significant positive ($P<0.05$) correlation with uric acid and HDL-C. It indicates that these changes are due to growth and development of the players. In the present study back strength of senior age group hockey players was noted 125.0 ± 2.9 kg. Studies on back strength of hockey players are limited at International levels. As hockey is played in similar field like football and the physiological requirements of the players are similar, therefore it can be expected that the strength of the hockey players would be similar to that of the football players. When comparing the back strength of the Japanese international football players 148.8 kg [39], it has been noted that the back strength of the Indian hockey players was less. In hockey grip strength may have importance in handling

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the stick during practice and competition. The grip strength (R/L) of (37.2 ± 0.9 kg/ 33.6 ± 1.9 kg) was noted in Indian senior elite hockey players in the present study. Similar observations on South African players reported higher grip strength (54 ± 8 kg) [28] than the Indian players of the present study. The strength of Indian hockey players was found lower than that of their international counterparts. As strength was important for the game of hockey Indian players should improve their strength to achieve success in the International competitions.

It is believed that a pronounced increase in the urea and uric acid concentration indicates strong influence of a training session, whereas normalization of the urea and uric acid level in blood is an index of time to perform subsequent strenuous training sessions [6]. The serum urea and uric acid level has been considered as an indicator of overtraining [6]. In the present study, significantly higher ($P<0.05$) level of serum urea and uric acid were noted in the U23 and senior age group players when compared with U16 and U19 age group players. This higher urea and uric acid level might be due to increased training load in the senior players compared with junior players [6]. Another reason for the increased urea and uric acid level is the degradation of adenonucleotides [31-32].

Lipids and lipoprotein profile indicate the cardiovascular and the metabolic status of the athlete [7, 40]. Activity levels have significant impact on the lipids and lipoprotein levels of the athletes [7]. In this study, a significant increase ($P<0.05$) in total cholesterol, triglyceride, HDL-C and LDL-C level was observed from lower age category to higher age category players. Lower level of total cholesterol, triglyceride, HDL-C and LDL-C was noted in U16 age group players when compared to the senior players. The results indicated that maturation process has positive relationship with the lipids and lipoproteins levels of the athletes. Similar observations have been reported by many researchers [7, 40].

Conclusions

Age wise changes were reflected on various parameters like body fat, aerobic capacity, anaerobic power, strength, haemoglobin, urea, uric acid, and lipid profile of the field hockey players. The unique profile of age related changes should be taken into consideration while selecting and administering training to the players. As the studies on field hockey players are limited in India, the data of the present study can be a handy tool and can act as a frame of reference for selection of field hockey players of different age groups.

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