ABSTRACT

The aim of this study was to investigate the effects of training on anthropometric, physiological and biochemical variables of Indian under 19 year field hockey players. A total of 30 male field hockey players (U19, age: 16.00-18.99 yr, 17.7 ± 0.5 yr) volunteered for this study. The training sessions were divided into 2 phases (a) Preparatory Phase (PP, 8 weeks) and (b) Competitive Phase (CP, 4 weeks). The training programme consist of aerobic, anaerobic and skill development, and were completed 4 hrs/day; 5 days/week. Selected variables were measured at zero level (baseline data, BD) and at the end of PP and CP. A significant (P<0.05) reduction in body fat, recovery heart rate, hemoglobin, total cholesterol, LDL; and significant (P<0.05) increase in LBM, VO\textsubscript{2max}\textsuperscript{a}, anaerobic power, back and grip strength, serum urea, serum uric acid, HDL level were noted among the players after the training. However, no significant difference was observed in stature, body mass, maximal heart rate (HR\textsubscript{max}), and triglyceride level of the players after the training. The present study may provide useful information to the scientist and coaches to develop their training programme for the young field hockey players.

Key Words: Hockey, Training, Body fat, VO\textsubscript{2max}\textsuperscript{a}, Anaerobic power, Lipid profile.
INTRODUCTION

Field hockey is a sport with a long history that has undergone quite rapid and radical changes. The advent of the synthetic playing surface has changed the technical, tactical and physiological requirements of the game at all levels, but in particular at the elite level. To achieve the best possible performance, the training has to be formulated according to the principles of periodization (8). The training induced changes observed in various parameters can be attributed to appropriate load dynamics.

Physique and body composition have an important role for playing field hockey (36, 42, 44, 50). In field hockey a lot of movements and skills are involved so a high level of physical demand is required for match play (36, 42, 44, 50). The game of field hockey involves jogging, sprinting in varied directions with and without ball. As the players have to cover a big area in the ground during attack and defence therefore, the game demands for aerobic as well as anaerobic fitness (7, 17, 22, 24). 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 in field hockey. The players better suited to cope with the demands of the game reach the elite level (7, 17, 22). The intermittent high intensity pattern of activity during the match requires a high function of both the aerobic and anaerobic energy delivery pathways (7, 17, 22, 50). Moreover, power and strength has great impact over the game, which is required during sprinting and in execution of various skills with the ball (7, 17, 22, 42).

During aerobic exercise the demand of oxygen increases at the working muscle, therefore an optimum level of hemoglobin is required to perform at the highest level with for high intensity sports (39, 49). The serum level of urea and uric acid are used for assessment of training related stress (52). During the field hockey training these parameters may be evaluated at regular intervals to assess the training load imposed on the athlete. 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 (31). Elevated plasma cholesterol concentrations have been implicated in the development of coronary artery disease (CAD) (1, 31).

This study was focused on the field hockey players as the game is popular and played throughout the world. The anthropometric, physiological and biochemical variables have important role for the evaluation of training of the athletes. Studies on these parameters of field hockey players are lacking in India. In view of the above, a study was undertaken to investigate the effect training on selected anthropometric, physiological and biochemical variables of under 19 years field hockey players.
MATERIAL AND METHODS

Subjects

A total of 30 Indian Under 19 years elite male (U19, age: 16.00-18.99 yr, 17.7 ± 0.5 yr) regularly playing competitive field hockey for last 4-7 years, volunteered for this study. The sportsmen represented India in different International competitions including Junior World cup, Junior World Championship and Junior Asian Championship etc. The selected anthropometric, physiological and biochemical parameters were measured in the laboratory at the beginning of the training (baseline data, BD) and at the end of each training phase (Preparatory Phase, PP and Competitive Phase, CP). 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°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 Institute.

Training

After taking the base line data (BD, zero level) the players went through a training programme. The training sessions were divided into 2 phases: (i) Preparatory Phase (PP, 8 weeks), and (ii) Competitive Phase (CP, 4 weeks) and the data were taken at each phase of training. The training sessions were followed 5 days/week. The volume and intensities of the training components also varies in each phase of training. In the preparatory phase, the volume and intensity of training increased gradually. On the other hand, in the competitive phase the training volume and intensity was changed according to the competition schedule. Highly specified training related to field hockey and practice match play was followed in the competitive phase. The players completed 2 hours of training in morning sessions to improve the physical fitness of the players. In the evening sessions 2 hours of technical and tactical training was completed, including dribbling, tackle, set up movements, penalty corner, penalty shootout and match practice etc. The training schedule, type of training, volume and intensity is shown in table 1.
### Table 1.

**General training schedule for the field hockey players**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
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<tr>
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</table>

<table>
<thead>
<tr>
<th>Training phase</th>
<th>Phase Sub-phase</th>
<th>Zero Level</th>
<th>Preparatory</th>
<th>Specific preparation</th>
<th>PC</th>
<th>Competition</th>
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<tbody>
<tr>
<td>Strengthen</td>
<td>Baseline</td>
<td>AA</td>
<td>Maximal</td>
<td>Strength</td>
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</tr>
<tr>
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<td>Aerobic</td>
<td>Anaerobic</td>
<td>Endurance</td>
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<td>Speed</td>
<td>General</td>
<td>Specific</td>
<td>Specific</td>
<td>Speed</td>
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<td></td>
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<tr>
<td>Skill Acquisition</td>
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<td>Foundation</td>
<td>Advanced</td>
<td>Skill Acquisition</td>
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<td>Stimulation</td>
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<tr>
<td>Macro cycles</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
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<tr>
<td>Micro cycles</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peaking index</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testing dates</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Training factors</th>
<th>Volume</th>
<th>Intensity</th>
<th>Peaking</th>
<th>Phys prep</th>
<th>Tech prep</th>
<th>Tact prep</th>
<th>Psych prep</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>100</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>1-80%</td>
<td>70-90%</td>
<td>70-95%</td>
<td>50-55%</td>
<td>40-45%</td>
<td>10%</td>
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<tr>
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<td>70-75%</td>
<td>40-45%</td>
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<td>30%</td>
<td>35%</td>
<td>35%</td>
<td>20%</td>
</tr>
<tr>
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<td>60-70%</td>
<td>80-90%</td>
<td>&gt;90%</td>
<td>30%</td>
<td>35%</td>
<td>35%</td>
<td>30-35%</td>
</tr>
</tbody>
</table>

PC = Pre Competition, AA = Anatomical Adaptation.
Protocol

Measurement of Anthropometric Variables

Body mass (weight) was measured with the accurately calibrated electronic scale (Seca Alpha 770, UK) to the nearest 0.1 kg, and stature (height) with stadiometer (Seca 220, UK) recorded to the nearest 0.5 cm (28). Body density was estimated from the sum of the skin-fold sites based on the standard procedure (13) and estimated percentage body fat was calculated using standard equation (46). Lean body mass (LBM) was calculated by subtracting fat mass from total body mass.

Measurement of Physiological Variables

Treadmill (Jaeger, LE 500, Germany) test was performed to determine the cardiovascular status of the players during maximal exercise. The maximum oxygen consumption ($VO_{2\text{max}}$) was measured following standard methodology (5). 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. Anaerobic power was measured using cycle ergo-meter (Jaeger, LE 900, Germany) following the Wingate anaerobic test (25). Strength of the grip and back was measured with the help of dynamometers following standard procedure (28).

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 (37). Serum urea (55) and uric acid (33) were determined calorimetrically. Serum triglycerides (45), serum total cholesterol (TC) (56) and high-density lipoprotein cholesterol (HDL-C) (56) were determined by enzymatic method. Low-density lipoprotein cholesterol (LDL-C) was indirectly assessed following standard equation (18).

Statistical Analysis

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

RESULTS

Effect of Training on Anthropometric Characteristics of Under 19 years Field Hockey Players

A significant (P<0.05) reduction in percent body fat was noted in preparatory and competitive phase of training when compared to base line data. However, a significant (P<0.05) increase in LBM was noted among the players when comparing base line data with that of the preparatory phase and competitive phase. No significant difference was observed in stature and body mass of the field hockey players after the training programme (Table 2).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>BD</th>
<th>PP</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature (cm)</td>
<td>170.3 ± 3.4</td>
<td>170.3 NS ± 3.5</td>
<td>170.3 NS ± 3.4</td>
</tr>
<tr>
<td>Body Mass (kg)</td>
<td>60.7 ± 3.7</td>
<td>60.0 NS ± 3.7</td>
<td>59.2 NS ± 3.4</td>
</tr>
<tr>
<td>Body Fat (%)</td>
<td>15.5 ± 1.4</td>
<td>14.3* ± 1.1</td>
<td>14.1* ± 1.4</td>
</tr>
<tr>
<td>LBM (kg)</td>
<td>46.2 ± 4.1</td>
<td>47.4* ± 3.1</td>
<td>47.8* ± 3.1</td>
</tr>
</tbody>
</table>

Each values represents mean ± SD. Computed using alpha = 0.05; * when compared to BD, NS= not significant; BD=Base Line Data, PP= Preparatory Phase, CP= Competitive Phase; LBM= Lean Body Mass.

Effect of Training on Physiological Characteristics of Under 19 years Field Hockey Players

In the present study, a significant (P<0.05) increase in VO_{2max}, anaerobic power, back strength and grip strength was observed among the field hockey players
when comparing base line data with that of the preparatory and competitive phases. However, a significant (P<0.05) reduction in recovery heart rate was noted in preparatory and competitive phases of training when compared to base line data. No significant change was observed in maximal heart rate (HRmax) of the field hockey players following the training programme (Table 3).

**Table 3.**

*Effect of Training on Physiological Characteristics of Under 19 years Field Hockey Players*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>BD</th>
<th>PP</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO&lt;sub&gt;2max&lt;/sub&gt; (ml kg&lt;sup&gt;-1&lt;/sup&gt; min&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>57.0 ± 3.9</td>
<td>59.8* ± 3.3</td>
<td>59.7* ± 3.2</td>
</tr>
<tr>
<td>HRmax (beats min&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>190.5 ± 2.5</td>
<td>190.3&lt;sub&gt;NS&lt;/sub&gt; ± 2.9</td>
<td>189.1&lt;sub&gt;NS&lt;/sub&gt; ± 2.7</td>
</tr>
<tr>
<td>RHR1 (beats min&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>152.5 ± 2.2</td>
<td>149.4* ± 2.7</td>
<td>149.0* ± 3.0</td>
</tr>
<tr>
<td>AP (W kg&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>11.3 ± 0.9</td>
<td>12.8* ± 1.1</td>
<td>13.0* ± 1.1</td>
</tr>
<tr>
<td>BST (kg)</td>
<td>113.3 ± 3.9</td>
<td>116.8* ± 2.3</td>
<td>116.9* ± 3.4</td>
</tr>
<tr>
<td>GSTR (kg)</td>
<td>32.1 ± 1.5</td>
<td>33.4* ± 1.5</td>
<td>33.8* ± 1.4</td>
</tr>
<tr>
<td>GSTL (kg)</td>
<td>28.4 ± 1.9</td>
<td>29.9* ± 1.9</td>
<td>29.9* ± 1.8</td>
</tr>
</tbody>
</table>

Each values represents mean ± SD. Computed using alpha = 0.05; * when compared to BD, NS= not significant; BD=Base Line Data, PP= Preparatory Phase, CP= Competitive Phase; VO<sub>2max</sub> = maximal aerobic capacity, HR<sub>max</sub> = maximal heart rate, HRR1= recovery heart rate 1<sup>st</sup> min. AP= Anaerobic Power, BST= Back Strength, GSTR= Grip Strength of Right Hand, GSTL= Grip Strength of Left Hand.

**Effect of Training on Biochemical Characteristics of Under 19 years Field Hockey Players**

A significant reduction (P<0.05) in hemoglobin, total cholesterol and LDL level was noted in competitive phase when compared to base line data of the field hockey players. On the other hand, significant (P<0.05) increase in serum urea and HDLC was noted in preparatory and competitive phases when compared to base line data of the players. Further, when comparing competitive phase with that of the base line data a significant (P<0.05) increase in serum uric acid level was noted among the players. No significant change was noted in triglyceride level among the field hockey players when comparing base line data with that of the preparatory and competitive phases (Table 4 and 5).
Table 4.
Effect of Training on Hemoglobin, Urea and Uric Acid Levels of Under 19 years Field Hockey Players

<table>
<thead>
<tr>
<th>Parameters</th>
<th>BD</th>
<th>PP</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb (g dl⁻¹)</td>
<td>13.7 ± 0.6</td>
<td>13.5 NS ± 0.5</td>
<td>13.4* ± 0.7</td>
</tr>
<tr>
<td>Urea (mg dl⁻¹)</td>
<td>26.5 ± 1.7</td>
<td>27.7* ± 1.9</td>
<td>28.7*# ± 2.7</td>
</tr>
<tr>
<td>UA (mg dl⁻¹)</td>
<td>3.6 ± 0.5</td>
<td>3.8 NS ± 0.6</td>
<td>3.9* ± 0.6</td>
</tr>
</tbody>
</table>

Each values represents mean ± SD. Computed using alpha = 0.05; * when compared to BD, # when compared to PP, NS= not significant; BD=Base Line Data, PP= Preparatory Phase, CP= Competitive Phase; Hb= Heamoglobin, UA= Uric Acid.

Table 5.
Effect of Training on Lipids and Lipoproteins Profiles of Under 19 years Field Hockey Players

<table>
<thead>
<tr>
<th>Parameters</th>
<th>BD</th>
<th>PP</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (mg dl⁻¹)</td>
<td>158.2± 5.2</td>
<td>156.7* ± 5.3</td>
<td>155.3* ± 4.6</td>
</tr>
<tr>
<td>TG (mg dl⁻¹)</td>
<td>89.6 ± 5.9</td>
<td>88.5 NS ± 4.7</td>
<td>87.7 NS ± 4.9</td>
</tr>
<tr>
<td>HDLC (mg dl⁻¹)</td>
<td>39.2 ± 3.1</td>
<td>41.9* ± 2.7</td>
<td>42.0* ± 2.9</td>
</tr>
<tr>
<td>LDLC (mg dl⁻¹)</td>
<td>101.1 ± 4.9</td>
<td>98.0* ± 4.2</td>
<td>97.3* ± 5.5</td>
</tr>
</tbody>
</table>

Each values represents mean ± SD. Computed using alpha = 0.05; * when compared to BD, NS= not significant; BD=Base Line Data, PP= Preparatory Phase, CP= Competitive Phase; TC= total cholesterol, TG= triglyceride, HDLC= high density lipoprotein cholesterol, LDLC= low density lipoprotein cholesterol.

DISCUSSION

Performance of the hockey players is affected by body composition and physique (22). A lean body is desirable for sports like field hockey (36, 42, 50, 53). A low-body fat may improve athletic performance by improving the strength-to-weight ratio (30, 54). Excess body fat adds to the load without contributing to the body’s force-producing capacity (30, 54). A significant (P<0.05) reduction in percent body fat was noted in preparatory and competitive phase when compared...
to base line data of the field hockey players. In addition, when comparing base line data with that of the preparatory phase and competitive phase a significant (P<0.05) increase in LBM was noted among the players. The possible reason for reduction in body fat might be endurance training, which increases greater utilization of fat (30, 54). Similar findings were also noted by some researchers, who studied on field hockey players and reported that percent body fat was significantly lower in-season and postseason vs. preseason (4). Therefore, it can be stated that field hockey players can accumulate body fat in the pre-season and lose body fat during preparatory phase and competitive phase of training. This might be due to intensive training during preparatory phase and high level of performance during the competitive phase. In this study no significant difference was observed in stature and body mass of the field hockey players after the training programme which might be due to the shorter duration of the training. It has been reported that short term exercise training has no significant effect on body mass of the sports persons (30, 54).

Aerobic capacity certainly plays an important role in modern field hockey and has a major influence on technical performance and tactical choices (17, 20). The present study showed a significant increase in relative VO_{2\text{max}} among the field hockey players when comparing base line data with that of the preparatory and competitive phases. The increase in relative VO_{2\text{max}} after training might be due to an increase in the systemic a-v O2 difference and stroke volume (30, 54). These changes might be because of the increase volume of endurance training in preparatory phase. It shows that VO_{2\text{max}} of the hockey players may improve with training. The increased aerobic activity increases the myoglobin content in the muscle due hypertrophy of the exercised muscles. Thus increased muscle mass also increases the blood supply and eventually enhances the capacity of the muscle to work for long duration (30, 54). The observation of the present study is supported by the findings of the other investigators (4, 17, 20). The VO_{2\text{max}} of professional field hockey players does improve significantly in the preparatory phase when there is an emphasis on aerobic training (4, 17, 20). Ideally, endurance training for hockey players should be carried out using the ball, because the player motivation is also normally considered to be higher when the ball is used. The players might then additionally develop technical and tactical skills similar to situations experienced during the game.

Heart rate increases with an increase in work intensity and shows linear relationship with work rate (5). 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 (30, 54). The heart rate recovery curve is an excellent tool for tracking a person’s progress during a training program (30). Heart rate recorded during recovery after maximal exercise decreased significantly (P<0.05) in the preparatory and competitive phases when compared to base line data among the field hockey players. It has
been observed that training reduces the rise in heart rate during exercise and hastens the fall in heart rate during recovery (30, 54). Exercise cardio acceleration results from release of parasympathetic inhibition at low exercise intensities and from both parasympathetic inhibition and sympathetic activation at moderate intensities (30, 54). Nevertheless, parasympathetic activation is considered to be the main mechanism underlying exponential cardio deceleration after exercise (30, 54). The players might have been adapted to the load and no further increase in load dynamics might have been stressed on. During the match play the activities are not continuous; instead it is intermittent that means it involves short sprinting and casual recovery. The players perform running with the ball and without the ball during match play. Thus less increase in heart rate during exercise and rapid fall in heart rate during casual recovery may help the player to perform better (30, 54). On the other hand, no significant change was noted in HRmax and resting heart rate of the players after the training. This might be due to shorter duration of the training. It has been seen that short term exercise has no significant effect on HRmax (30, 54). The results of the present study suggest that the strain on the circulatory system during playing hockey is relatively high. Exercising at this intensity should provide a good training stimulus, provided such participation is frequent enough.

The game of hockey demands high anaerobic power as accelerate and decelerate quickly is the part of the game (20, 41, 42, 44). It is acceleration that is critical to hockey performance rather than maximal speed (20, 41, 42, 44). A high anaerobic power is essential for such activities. In the present study, significant (P<0.05) increase in anaerobic power was noted among the field hockey players in preparatory phase and competitive phase of training when compared to base line data. This might be due to training in the players. Playing field hockey involves intermittent activities i.e., short sprinting and casual recovery. Thus a high anaerobic power helps to develop sprint quality of the player. It would appear, therefore, that a high anaerobic power is desirable for success in top-class hockey (43). On the other hand, strength is the central component of a field hockey training program (16, 32, 47, 48). 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. Many activities in field hockey are forceful and explosive (e.g. tackling, jumping, hitting the ball, turning and changing pace). The power output during such activities is related to the strength of the muscles involved in the movements. Thus, it might be beneficial for a hockey player to have a high muscular strength, which also diminishes the risk of injury (21, 43). The results of the present study showed a significant (P<0.05) increase in back and grip strength in preparatory phase and competitive phase of training when compared to base line data of the field hockey players. Similar observation has been reported by many researchers (16, 32, 47,
They studied on field hockey players and reported that the strength increased after training. The game requirements are involving acceleration, deceleration and turning movements (43). Although the majority of the game is spent in low-level activity such as walking and light jogging, repeated back-to-back sprints make speed and tolerance to lactic acid an important characteristic in players (43). Therefore, sprint training regimens is beneficial to field hockey players.

Hemoglobin concentration in blood which is mainly used for the transport of oxygen from blood vessels to exercising muscles, and transport of carbon dioxide from working muscles to blood vessels. Hemoglobin also represents the iron status of the body (27,29, 39, 49). In the present study a significant reduction (P<0.05) in hemoglobin was noted in competitive phase of training when compared to base line data of the field hockey players. During the pre-training period the training load was lesser than preparatory phase and competitive phase; therefore, reduced hemoglobin level was observed in the latter phases. Moreover, as the training load increased in the competitive phase, the declined in hemoglobin level was more prominent when compared with the pre-training period. Similar observations have been noted by many researchers in their recent studies (27,29, 39, 49). Studies on professional athletes showed that hemoglobin values were higher at the beginning of the competition season, and then declined in well-trained athletes (27,29, 39, 49). It can be suggested that the decline in hemoglobin level might be due to haemolysis (9, 19, 49). Intravascular haemolysis is one of the most emphasized mechanisms for destruction of erythrocytes during and after physical activity (26, 40). In addition, exercise training induced reduction in hemoglobin concentration also might be due to hemodilution which is a common physiological effect of endurance training also exist among the well trained athletes due to increased in plasma volume (27,29,38). A recent study reported declined haematocrit during the race and continued falling on the next day with a corresponding rises in plasma volume following an ultra endurance cycling. They reported that the impact on the plasma volume is pronounced leading to marked haemodilution post-exercise (38). Another study reported a decrease in hemoglobin concentration during the post race recovery period following an ultra marathon race and that the greatest reduction in hemoglobin concentration was observed 48 hours after the race (12). They suggested that this reduction in hemoglobin concentration is due to hemodilution (12).

The serum urea and uric acid level has been considered as an indicator of overtraining. In this study, significant increase (P<0.05) in serum urea level was noted in the field hockey players in preparatory phase and competitive phase of training when compared to base line data. In addition, when comparing preparatory phase with that of the competitive phase significant (P<0.05) increase in serum urea level was noted among the players. Moreover, significant increase (P<0.05) in serum uric acid level was also noted in the field hockey players in competitive phase of training when compared to base line data. Increased level of serum urea
and uric acid were observed after training, but the urea and uric acid level were found to be within the normal range. The highest level of urea and uric acid were noted in the competitive phase when the training load was highest. 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 (11). The possible reason for the increased urea level is the breakdown of proteins. Similar observations have been reported by many researchers (2, 29). It has been reported that prolonged exercises have been shown to cause increased urea concentration in the blood, liver, skeletal muscles, urine, and sweat (2, 6, 29, 38). This considered as an augmented urea production. The increased uric acid level is also attributed the degradation of adenonucleotides (2, 11, 29). Uric acid has been found in sweat and urine collected during exercise (11). In fact, despite being an end product of the purine nucleotide system, uric acid scavenges OH₂ radicals as well, and there is evidence that it may be an important biological scavenger against free radicals in human plasma and in skeletal muscle during and after acute hard exercise (51). This might be one of the reasons for increase in urea and uric acid level after exercise training (51).

Lipids and lipoprotein profile indicate the cardiovascular and the metabolic status of the athlete (1, 10, 31, 34, 35). Activity levels have impact on the lipids and lipoprotein levels of the athletes. As the training load increased from pre-training period to preparatory phase and competitive phase, the level of total cholesterol and LDL-C were decreased significantly (P<0.05) where as the level of HDL-C increased (P<0.05) gradually. However, when comparing base line data with that of the preparatory and competitive phases no significant change was noted in triglyceride level among the field hockey players. Therefore, it can be stated that the training load has a negative relation with total cholesterol and LDL-C; and a positive relation with HDL-C level of the athletes. The possible reason for the reduction in total cholesterol and LDL-C; and elevation in HDL-C is that exercise especially, which increases metabolism and utilization of blood lipids and lipoprotein for energy production (54). However, no significant change was noted in triglyceride level of the players after the training. This might be due to the short duration of the training or improper optimization of the training load. Our findings are in conformity with the observations of other researchers in their recent studies. Cross-sectional studies also reported an increase in HDL-C level and decrease in triglyceride level after exercise (3, 14, 15, 23, 31). A recent study showed significant increase in HDL-C level and decrease in LDL-C level, with no change in triglyceride after 9 weeks of training (3, 11). Another study reported that 4 weeks of aerobic exercise training significantly decreased the levels of total cholesterol, LDL-C, and increased HDL-C (1, 3). Similar observations have been reported in the present study.
CONCLUSIONS

It may be concluded that these changes are due to training as well as due to participating in an increasing number of competitions. The introduction of synthetic playing surface has changed the game towards more of anaerobic side therefore, the game demands for high anaerobic power and strength. However, development of high aerobic capacity is essential for field hockey as the players has to cover a big area in the ground during the game. Regular monitoring of hemoglobin; serum urea and uric acid; lipids and lipoproteins profiles of the field hockey players is essential to optimize their health status which has direct relation with their performance. The unique profile should be taken into consideration while 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 monitoring of training of field hockey players of different age groups. This would enable the coaches to assess the current status of an athlete and the degree of training adaptability and provide an opportunity to modify the training schedule accordingly to achieve the desired performance.

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