

TRAINING INDUCED CHANGES ON PHYSIOLOGICAL AND BIOCHEMICAL VARIABLES OF YOUNG INDIAN FIELD HOCKEY PLAYERS

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Abstract. The present study aims to find out the training induced changes on different physiological and biochemical parameters in young Indian field hockey players. A total of 30 Indian male field hockey players (age range 14-16 yrs) regularly playing competitive field hockey were selected; a training programme consist of aerobic and anaerobic exercise were followed for 6 wks and 12 wks respectively. Results showed a significant decrease ($P<0.05$) in body fat, and a significant increase ($P<0.05$) in LBM following both 6 wks and 12 wks of training. Strength of backs and handgrip muscles were also increased significantly ($P<0.05$) after the training. Significant reduction ($P<0.05$) in heart rates during sub-maximal exercises, maximal exercises and recoveries were noted after both the training programme. Moreover, significant increase ($P<0.05$) in aerobic capacity and anaerobic power were observed after the training. Further, significant reductions ($P<0.05$) were noted in hemoglobin, total cholesterol, triglyceride and LDLC after the training. On the other hand plasma levels of urea, uric acid and HDLC were increased significantly ($P<0.05$) following the training. Present study showed a decrease in body fat and the plasma levels of cholesterol as well as LDLC and increase in HDLC, which is beneficial for good health and better performance. However, reduction in hemoglobin and increase in plasma urea and uric acid may be due to increased training load. Since the data on field hockey players are limited in India, therefore the present study may provide useful information to the coaches to develop their training programme.

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Key words: Heart rate - VO_{2max} , anaerobic power - Lipid profile - Training

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Introduction

Field hockey is a sport with a long history that has undergone quite rapid and radical change within the past decade. 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. In order to adapt to the technical evolution within the game, the players have to develop physiologically to meet the physical demand required at elite levels [21]. The game of field hockey involves short sprinting as well as movement with and without the ball. Therefore, playing hockey requires both aerobic and anaerobic components.

Physique and body composition play an important role for the selection of players [21-23]. Moreover, back and grip strength has great impact over the game, which is required during hitting and passing the ball [21-23]. Cardiovascular status, as indicated by heart rate recorded during exercise and recovery, plays a vital role for the identification and selection of players as well as planning for training [12]. Monitoring biochemical parameters such as urea, uric acid and lipid profiles are of advantage in regulating the training load, nutrition, and maintaining the health status of the players [2,5,6,9,11].

Training has significant impact on the performance. Data on training on the junior field hockey players are lacking in India. Therefore, in the present study, emphasis has been focused on determining the training induced changes on different physiological and biochemical characteristics of young Indian field hockey players.

Materials and Methods

Subjects: A total of 30 male (age range 14-16 years), regularly playing competitive field hockey athletes were selected after medical check up from the National training camps at Sports Authority of India. An average of 2 hours of training in morning sessions was generally completed by the players. The training involves both aerobic and anaerobic training. The evening hours were similar however technical training (skill developments) sessions were completed. The training plans was divided in to three phases (i) transition phase (TP= 0 weeks); (ii) preparatory phase (PP=6 weeks); (iii) competitive phase (CP=12 weeks) and completed 5 days per week. Physiological and biochemical variables 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.



Measurement of physiological parameter: Body mass was measured with the accurately calibrated electronic scale (Seca Alpha 770, UK) to the nearest 0.1 kg and stature with a stadiometer (Seca 220, UK) recorded to the nearest 0.1 cm. Body density was estimated from the sum of the skin-fold sites [8]. Estimated percentage body fat was calculated from a standard equation [24]. Lean body mass (LBM) was calculated by subtracting fat mass from total body mass. Grip and back strength were measured by dynamometers (Senoh, Japan) [15].

Treadmill (Jaeger LE 500; Jaeger, Germany) tests were performed at 0% gradient to determine the cardiovascular status of the players during sub-maximal and maximal exercise. Heart rate responses during rest, exercise and recovery were noted in every 5 s using a heart rate monitor (Polar, Finland). The maximum oxygen consumption ($\text{VO}_{2\text{max}}$) was measured following standard methodology using computerized respiratory gas analyzer (Oxycon Champion, Germany) [1]. Anaerobic power was measured using a cycle ergometer (Jaeger LE 900; Jaeger, Germany) [14].

Measurement of biochemical parameters: A 5 ml of venous blood was drawn from an antecubital vein after 12 hour fast and 24 hour after the last bout of exercise. Hemoglobin (Hb), urea and uric acid were measured following standard methodology [19]. Total cholesterol (TC), triglyceride (TG) and high-density lipoprotein cholesterol (HDL) were determined by enzymatic method using Boehringer Mannheim kit [19]. Low-density lipoprotein cholesterol (LDL) was calculated from a standard equation [10]

Statistical analysis: Data were presented as mean and standard deviation (SD). Repeated measured analysis of variance (ANOVA) followed by multiple two-tail t-test with Bonferroni modification was used to determine whether the differences of means in each parameter between the groups were significant. Differences were considered significant when $P < 0.05$ [7]. Accordingly, a statistical software package (SPSS-10) was used.

Results

Significant decrease ($P < 0.05$) in percentage body fat was noted after 6 wks and 12 wks of training when compared to that of transition phase. On the other hand significant increase ($P < 0.05$) in LBM was noted after both the training programmes. Strength of backs and hand grip strength showed a significant increase ($P < 0.05$) after 6 wks and 12 wks of training. No significant change was observed in stature and body mass (Table 1).



Table 1

Effect of training on body composition and strength of young India field hockey players

Groups	Stature (cm)	Body mass (kg)	LBM (kg)	Body fat (%)	BST (kg)	GSTR (kg)	GSTL (kg)
TP	163.5 ^a ±2.4	53.3 ^a ±2.9	42.0 ^a ±2.4	21.1 ^a ±2.0	106.4 ^a ±7.0	30.0 ^a ±2.5	26.5 ^a ±1.4
PP	163.6 ^a ±2.5	53.7 ^a ±3.0	44.0 ^b ±2.6	18.1 ^b ±2.0	110.6 ^b ±5.3	32.7 ^b ±2.1	29.1 ^b ±2.0
CP	164.1 ^a ±2.5	54.3 ^a ±2.2	45.9 ^c ±2.2	15.6 ^c ±2.4	117.0 ^c ±4.5	35.8 ^c ±1.5	31.8 ^c ±1.4

Heart rate recorded during sub-maximal exercise decreased significantly ($P<0.05$) after 6 wks and 12 wks of training when compared to that of the initial phase. Significant reduction ($P<0.05$) in heart rate was also noted after maximal exercise and during recovery following the 6 wks and 12 wks of training. However, no significant change was noted in resting heart rate following the training (Table 2). Further, a significant increase ($P<0.05$) in maximal aerobic capacity (VO_{2max}) and anaerobic power was noted after 12 wks of training when compared to that of the initial phase (Fig. 1).

Table 2

Effect of training on heart rate variables of young India field hockey players

Groups	RHR (b·min ⁻¹)	HR1 (b·min ⁻¹)	HR2 (b·min ⁻¹)	MHR (b·min ⁻¹)	MRR1 (b·min ⁻¹)	HRR2 (b·min ⁻¹)	HRR3 (b·min ⁻¹)
TP	66.5 ^a ±3.2	127.1 ^a ±4.6	145.8 ^a ±2.0	189.0 ^a ±2.4	161.0 ^a ±3.7	139.7 ^a ±1.8	122.0 ^a ±3.0
PP	67.0 ^a ±3.2	124.0 ^b ±3.7	143.9 ^b ±2.9	186.9 ^b ±4.1	158.3 ±4.8	136.2 ^b ±2.0	119.8 ^b ±3.2
CP	64.7 ^a ±5.6	120.5 ^c ±3.4	138.8 ^c ±3.6	184.5 ±3.6	154.3 ^c ±5.3	132.8 ^c ±2.6	114.6 ^c ±3.4



A significant reduction ($P < 0.05$) in hemoglobin concentration was observed following 6 wks and 12 wks of training (Fig 2). On the other hand a significant increase ($P < 0.05$) in serum urea and uric acid were noted after 6 wks and 12 wks of training (Fig 2). Further, significant elevation ($P < 0.05$) was noted in blood level of HDLC after 6 wks and 12 wks of training (Table 3). On the contrary, significant reduction ($P < 0.05$) in triglyceride, total cholesterol, LDLC, the ratio of total cholesterol to HDLC and ratio of LDLC to HDLC were noted after the training (Table 3).

Fig 1a

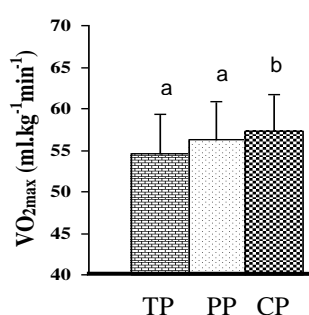
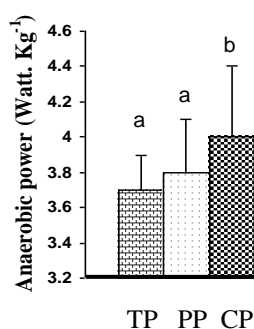


Fig 1b

**Fig. 1**

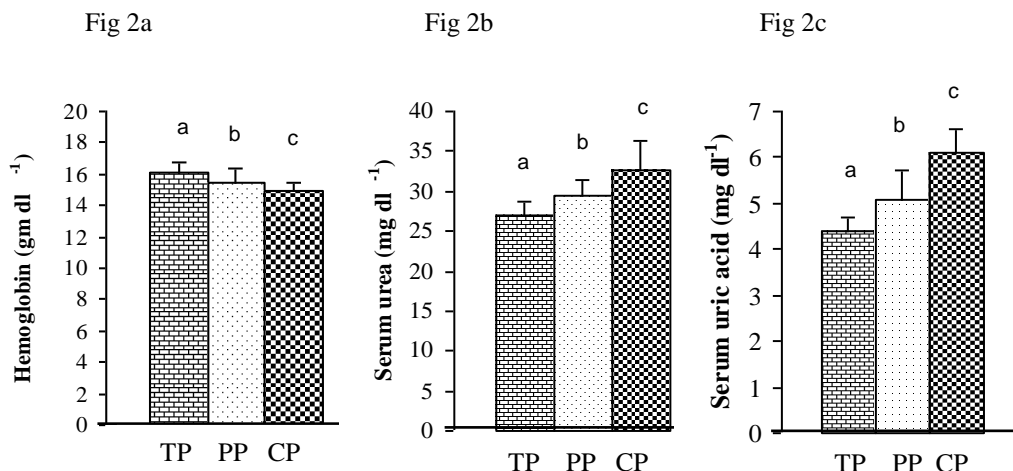
Effect of training on maximal aerobic capacity and anaerobic power of young Indian field hockey players

Table 3

Effect of training on lipids and lipoproteins profiles of young Indian field hockey players

Groups	TC (mg·dl ⁻¹)	TG (mg·dl ⁻¹)	HDLC (mg·dl ⁻¹)	LDLC (mg·dl ⁻¹)	TC/HDLC	LDLC/HDL C
TP	187.0 ^a ±7.0	105.8 ^a 10.1±	37.5 ^a 2.5±	128.4 ^a 7.0±	5.0 ^a 0.3±	3.4 ^a 0.3±
PP	172.7 ^b 13.1±	94.0 ^b ±9.3	40.9 ^b ±5.1	113.0 ^b ±13.2	4.3 ^b 0.6±	2.8 ^b ±0.5



**Fig. 2**

Effect of training on hemoglobin, serum urea and uric acid of young Indian field hockey players

Abbreviations to Tables and Figures:

Each values represents mean \pm SD; ANOVA followed by multiple two-tail t-test with Bonferroni modification was followed; in each vertical column the mean with different superscript (^{a, b, c}) differ from each other significantly, $P < 0.05$;

TP – transition phase; PP – preparatory phase; CP – competitive phase; LBM – lean body mass; BST – back strength; GSTR – grip strength right hand; GSTL – grip strength left hand; RHR – resting heart rate; HR1 – sub-maximal heart rate 1st min; HR2 – sub-maximal heart rate 2nd min; MHR – maximal heart rate; HRR1 – recovery heart rate 1st min; HRR2 – recovery heart rate 2nd min; HRR3 – recovery heart rate 3rd min; VO_{2max} – maximal aerobic capacity; AP – anaerobic power; TC – total cholesterol; TG – triglyceride; HDLC – high density lipoprotein cholesterol; LDLC – low density lipoprotein cholesterol.

Discussion

Since the ancient times, it has been believed that a suitable physique is important to achieve success in particular sports [22]. The measurement of height and weight has some importance in selecting sports personal [18,23]. The

estimation of body composition permits the quantification of gross size of an individual into two major structural components namely fat mass and lean body mass [22]. The body composition especially in sports persons is a better guide for determining the desirable weight rather than using the standard height-weight-age tables of normal population, because of the presence of high proportion of muscular content in their total body composition. This appraisal provides an important baseline to develop an effective training program. Stature and body mass have significant impact on elite hockey teams [21,22]. Tall players have an advantage in playing positions such as goalkeeper, forward and defense. However, a standard body mass is required for every playing positions. The present study shows no significant change in stature among the players after the training. Although an increasing tendency was noted in body mass but the results were not significant. As the training period was short therefore no significant change was noted in stature and body mass. Stature and body mass have significant impact on hockey teams and a standard height and body mass is required for every playing position [12,17,22,23].

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 [13,21]. The results of the present study have shown a significant increase in back and grip strength after both "6" weeks and "12" weeks of training. Responses to strength training were also proved by some earlier studies [23].

Heart rate increases with an increase in work intensity and shows linear relationship with work rate [1]. In the present study significant reductions in heart rates during rest, sub maximal exercise and recovery were noted after the training. It has been observed that training reduces the rise in heart rate during exercise and fasten the fall in heart rate during recovery. During the match play the activities are not continuous; instead it is intermittent that means it involves short sprinting and casual recovery. Some time running with the ball and some times with out the ball. Thus less increase in heart rate during exercise and rapid fall in heart rate during casual recovery may help the player to perform better. Heart rate becomes the only factor in increasing cardiac out put after stroke volume reaches its maximum level at about 40% of maximal work [1,20]. Since heart rate can increase from 50-190 beats per min (300-400 %) in well-trained sports persons, with an increasing stroke volume of about 50-75%, heart rate plays a key role in increased cardiac out put during exercise [1]. Significant reduction in heart rates during rest, sub-maximal,



maximal exercise and recovery were noted after the training sessions in the present study. It has been observed that training reduces the rise in heart rate during exercise and hastens the fall in heart rate during recovery [1,20].

The present study showed an increase in maximal aerobic capacity (VO_{2max}) in the young hockey players after the training. The maximum aerobic capacity for elite male players has been determined in several studies, with mean values between 56 and 69 $ml \cdot kg^{-1} \cdot min^{-1}$ [21]. Based on results obtained from elite European players, full backs and midfield players had the highest values and goalkeepers and central defenders the lowest. Nevertheless, the consistent observation of mean VO_{2max} values exceeding 60 $ml \cdot kg^{-1} \cdot min^{-1}$ in elite teams suggests the existence of a threshold below which an individual player is unlikely to perform successfully in top-class hockey [21,22]. The present study showed a mean VO_{2max} of 57.3 $ml \cdot kg^{-1} \cdot min^{-1}$ in the players after 12 weeks of training. It can be said that the VO_{2max} of Indian players being low compared to their European counterparts may lead to less success at International level. The present study also demonstrated that maximal aerobic capacity increases with training, this is largely because of 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.

Anaerobic power represents the highest rate of anaerobic energy released, where as anaerobic capacity reflects the maximal anaerobic energy production an individual can obtain in any exercise bout performed to exhaustion [14]. Although mean power output over 30 s on a cycle-ergometer has been used to evaluate the maximal performance of hockey players during short term exercise and thus, indirectly, their anaerobic power [21,22]. Present study showed significant increase in anaerobic power after the training. Playing hockey involve 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 [21]. This capability is reflected in the higher values for anaerobic capacity among goalkeepers, central defenders and strikers [21,22].

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 [6]. Present study has shown a decrease in hemoglobin concentration with the advancement of training among the players, which may be due to hemolysis of the red blood cells. This can be substantiated by nutritional



manipulation [6]. It has been observed that hemoglobin concentration to be 4% lower in highly trained runners than in controls [6]. The total amount of hemoglobin rather than its concentration in the blood is the determining factor for reaching a maximal $\dot{V}O_2$ [6].

The present study has shown increased level of urea and uric acid after both 6 weeks and 12 weeks of training. It may be suggested that increased level of urea and uric acid may be due to increased intensity of training and or, excessive intake of proteins and reduced excretion of urinary urea and uric acid. The main end product of protein metabolism is urea. Prolonged exercises have been shown to cause increased urea and uric acid concentration in the blood, liver, skeletal muscles, urine, and sweat [5]. Uric acid increases in blood, urine and sweat during prolonged exercise. Determination of serum urea and uric acid used as indicators of over training [25]. Therefore, monitoring of exercise stress through different biochemical parameters including serum urea and uric acid become common practice [11,25]. Therefore, the results of the present study indicated the higher intensity of training in the players.

In the present study a significantly decreased level of total cholesterol, triglyceride and LDLC were noted with the advancement of training. Further, a significantly higher level of HDLC was noted after the training among the players. Regular participation in physical activity is associated with lower plasma level of cholesterol, triglyceride and LDLC [9]. Level of fitness influences the lipid profile as physically fit and active person tend to have lower level of lipids than unfit or less active person. Lipoproteins are vehicles for transporting lipids to the sites of their metabolism in various tissues. The uptake of LDLC by cells is part of a homeostatic mechanism regulating the intracellular cholesterol metabolism and providing cholesterol for plasma membrane as an essential structural component. However, a high blood plasma concentration of cholesterol in the form of LDLC is the most important factor causing arteriosclerosis [2,9]. A high ratio of HDLC to LDLC, is reduced the likelihood of the development of arteriosclerosis [2,9]. Evidence has been collected that endurance training results in a decrease of total cholesterol and LDLC levels and an increase of HDLC concentration [2,9]. Similar observation was noted in the present study. Another study showed that the serum levels of HDLC and the ratio of HDLC to total cholesterol were increased in those players having more aerobic exercise in their training program [16]. Whereas, those players exposed more anaerobic training showed low concentration of HDLC to total cholesterol [16]

In the present study, training induced changes in different physiological and biochemical parameters have been noted in young Indian field hockey players. It



may be concluded that training improve the aerobic as well as the anaerobic fitness of the players. These changes were reflected on various physiological and biochemical variables like body fat, strength, lipid profile etc. Data on field hockey players are limited in India; therefore, the present study may provide a useful database to the coaches for preparing training schedules.

References

1. Astrand P.O., K.Rodhal (1970) Textbook of work physiology. McGraw-Hill., New York
2. Berg A., I.Frey, M.W.Basmstark, M.Halle, J.Keul (1994) Physical activity and lipoprotein lipid disorders. *Sports Med.* 17:6-21
3. Beunen G., B.M.Malina (1988) Growth and physical performance relative to the timing of the adolescent spurt. *Exerc.Sport Sci.Rev.* 16:503-546
4. Beunen G.P., R.M.Malina, J.Lefevre, A.L.Claessens, R.Renson, J.Simons (1997) Prediction of adult stature and noninvasive assessment of biological maturation. *Med.Sci.Sports Exerc.* 29:225-230
5. Carraro F., T.D.Kimbrough, R.R.Wolfe (1993) Urea kinetics in humans of two levels of exercise intensity. *J.Appl.Physiol.* 75:1180-1185
6. Casoni I., C.Barsetto, A.Cavicchi, S.Martinelli, F.Conconi (1985) Reduced hemoglobin concentration and red cells hemoglobinization in Italian marathon and ultra marathon runners. *Int.J.Sports Med.* 6:176-179
7. Das D., A.Das (1998) Statistics in biology and psychology. Academic Publ., Calcutta
8. Durnin J.V.G.A., J.Womersley (1947) Body fat assessed from total body density and its estimation from skin fold thickness: measurements on 481 men and women from 16 to 72 years. *Br.J.Nutr.* 32:77-97
9. Durstine J.L., W.L.Haskell (1994) Effects of exercise training on plasma lipids and lipoprotein. In: J.O.Holloszy (ed.) Exercise and Sports Science Reviews. Williams and Wilkins, London, pp. 77-521
10. Friedewald W.T., R.I.Levy, D.S.Fredrickson (1972) Estimation of the concentration of low-density lipoprotein cholesterol in plasma without use of the preparative ultracentrifuge. *Clin.Chem.* 18:499-501
11. Fry R.W., A.R.Morton, P.Garcia-Webb, D.Keast (1991) Monitoring exercise stress by changes in metabolic and hormonal responses over a 24-h period. *Eur.J.Appl.Physiol.* 63:228-234
12. Ghosh A.K, A.Goswami, P.Majumdar, D.N.Mathur (1991) Heart rate & blood lactate response in field hockey players. *Ind.J.Med.Res.* 94:351-356
13. Gorgorger A., G.M.Oettl, F.Tusker (2001) Anthropometry and muscle force measurement of German male national junior hockey player. *Sportverletz Sportschaden* 15:87-91



14. Inbar O., O.Bar-Or, J.S.Skinner (1996) The Wingate Anaerobic Test. Human Kinetics., Champaign, IL
15. Jonson B.L., J.K.Nelson (1996) Practical measurements for evaluation in physical education. Macmillan Publishing Co., London
16. Lehtonen A., J.Viikari (1980) Serum lipids in soccer and ice hockey players. *Metabolism* 29:36-39
17. Malhotra M.S., N.T.Joseph, J.S.Gupta (1974) Body composition and endurance capacity of Indian hockey players. *J.Sports Med.Phys.Fitness* 14:272-277
18. Manna I., M.Dhingra, G.L.Khanna (2002) Study of anthropometric and physiological profiles for the selection of under 14 years football players in scheme. *J.Sport Traumatol.* 4:53-58
19. Mukharjee K.L. (1997) Medical laboratory technology. A procedure manual for routine diagnostic tests. Vol I-III, McGraw-Hill Publ. Co. Ltd., New Delhi
20. Powers S.K., E.T.Howley (1997) Exercise Physiology. Brown & Benchmark Publ., Madison
21. Reilly T., A.Borrie (1992) Physiology applied to field hockey. *Sports Med.* 14:10-26
22. Reilly T., N.Secher, P.Snell, C.Williams (1990) Physiology of Sports. E. & F. N.Spon, London
23. Scott P.A. (1991) Morphological characteristics of elite male field hockey players. *J.Sports Med.Phys.Fitness* 31:57-61
24. Siri W.E. (1956) The gross composition of the body. In: C.A.Tobias and J.H.Lawrence (eds.) Advances in Biological and Medical Physics. Academic Press., New York, pp. 239-280
25. Urhausen A., W.Kindermann (2002) Diagnosis of over training: what tools do we have? *Sports Med.* 32:95-102

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