

Effect of Training on Morphological, Physiological and Biochemical Variables of Young Indian Soccer 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 soccer players. A total of 30 Indian male soccer players (age range 14-16 yrs) regularly playing competitive soccer were selected, a training programme consist of 6 wks and 12 wks of training was employed, and the effects were studied on different morphological, physiological and biochemical variables. Results showed a significant decrease ($P<0.05$) in body fat, and a significant increase ($P<0.05$) in LBM following the training programme. Strength of back and hand grip muscles were also increased significantly ($P<0.05$) after the training. Moreover, significant reduction in heart rates during rest, sub-maximal exercise, maximal exercise and recovery were noted following the training. Further, significant increase ($P<0.05$) in aerobic capacity and anaerobic power were observed after the training. Significant reduction ($P<0.05$) in haemoglobin, total cholesterol, triglyceride and LDLC were noted after the training. A significant increase in serum urea, uric acid and HDLC were noted after training. Since the data on the soccer players are limited in India therefore, the present study may provide useful information to the coaches to develop their training programme.

Key Words: Body Fat, Strength, VO_2 max, Anaerobic Power, Lipid Profile

Introduction

Soccer is unarguably the most popular sport world wide. The common aspect of the game is the necessity of teamwork to complement individual skills. Since soccer is a physical contact sport and lots of movements and skills are involved. A high level of physical demand is required for match play, which involves kicking, short sprinting, throwing, catching, trapping etc. The activities of the game include short sprinting as well as casual recovery movements. 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 (Reilly, 1996; Reilly et al., 2000a). Identification and selection of players at the young age

are essential; this helps the selectors and the coaches to produce a successful player of top level (Manna et al., 2002; Reilly et al., 2000b). Training helps to develop the strength, endurance as well as skills, and become more effective when given to young players (Bell and Rhodes, 1975; Berg et al., 1985; Jung et al., 2000; Reilly et al., 2000b; Strudwick et al., 2002).

Monitoring of training through different laboratory and field tests are performed to observe the training induced changes in different morphological, physiological and biochemical variables among the players. Apart from the skills and teamwork required for game play body composition, strength, aerobic capacity and anaerobic power as well as heart rate during

exercise and recovery have significant impact (Aziz *et al.*, 2000; Carraro *et al.*, 1993; Chin *et al.*, 1994; Urhausen and Kindermann, 2002). Moreover, biochemical profiles like hemoglobin, urea, uric acid, lipids and lipoproteins are also good indicators for monitoring of training and physical fitness (Berg *et al.*, 1994; Casoni *et al.*, 1985; Cerny 1975; Fry *et al.*, 1991; Manna *et al.*, 2004).

Studies on young soccer players are scanty. Moreover, studies on effect of training have not been observed on young soccer players in India. Therefore, the aim of the present study was to find out the effect of training on different morphological, physiological and biochemical parameters in young Indian soccer players.

Materials and Methods

Subjects and training

A total of 30 male (age range 14 - 16 years), regularly playing competitive soccer 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 sessions were divided into three phases (i) transition phase (TP= 0 weeks); (ii) preparatory phase (PP= 6 weeks); (iii) competitive phase (CP= 12 weeks) and were followed 5 days per week. Morphological, physiological and biochemical variables were measured in the laboratory. Each test was scheduled at the same time of day (\pm 1 hour) in order to minimize the effect of diurnal variation. The study was conducted at Sports

Authority of India and was approved by the ethical committee of the institute.

Measurement of morphological parameters

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 (Durnin and Womersley, 1974). Estimated percentage body fat was calculated from a standard equation (Siri, 1956). Lean body mass (LBM) was calculated by subtracting fat mass from total body mass. Grip and back strength were measured by dynamometers (India Medico Instruments, India) (Jonson and Nelson, 1996).

Measurement of physiological parameters

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 sec using a heart rate monitor (Polar, Finland). The maximum oxygen consumption (VO_{2max}) was measured following standard methodology using computerized respiratory gas analyser (Oxycon Champion, Germany) (Astrand and Rodhal, 1970). 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 breadth-by-breadth and measured from a mixing chamber using computerized respiratory gas analyser (Oxycon Champion, Jaeger, Germany).

Anaerobic power was measured using a cycle ergometer (Jaeger LE 900; Jaeger,

Germany) (Inbar et al., 1996). After a 10 min warm up the subject was asked to pedal as fast as possible with out resistance. Within 3 sec a fixed resistance of 0.075 kg per kg body mass was applied to the flywheel and the subject continuous to pedal “all out” for 30 sec. A computerized counter continuously recorded the flywheel revolutions in 5 sec intervals. Anaerobic power was measured using the software supplied by Jaeger, Germany.

Measurement of biochemical parameters

A 5 ml of venous blood was drawn from an antecubital vein after a 12 hour fast and 24 hours after the last bout of exercise. Hemoglobin (Hb), urea and uric acid were measured following standard methodology (Mukharjee, 1997). Total cholesterol (TC), triglyceride (TG) and high-density lipoprotein cholesterol (HDLC) were determined by enzymatic method using Boehringer Mannheim kit (USA) (Mukharjee, 1997). Low-density lipoprotein cholesterol (LDLC) was calculated from a standard equation (Friedewald et al., 1972).

Statistical analysis

Data were presented as mean and standard deviation (SD). 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 (Das and Das, 1998). Accordingly, a statistical software package (SPSS-10) was used.

Results

In the present study effects of different phases of training (preparatory phase-6 wks and competitive phase-12

wks) have been observed on different morphological, physiological and biochemical variables of young Indian soccer players. Significant decrease (P<0.05) in percentage body fat was noted after 12 wks of training. On the other hand significant increase (P<0.05) in LBM was noted after both 6 wks and 12 wks of training. Strength of backs and grip muscles were measured and the results showed a significant increase (P<0.05) in back strength after 12 wks and grip strength of right and left hands after both 6wks and 12 wks of training. Further, significant increase in body mass was noted after 12 wks of training among the players. However, no significant change was noted in stature following the training program (Table 1).

Table 1. Effect of training on body composition and strength on young India soccer players

Groups	Stature (cms)	Body Mass	LBM (kg)	Body Fat (%)	BST (kg)	GSTR (kg)	GSTL (kg)	
TP	Mean	168.5	52.0	41.8	19.6	105.8	30.9	29.7
	SD	± 5.2	± 1.3	± 1.8	± 4.0	± 12.2	± 3.3	± 2.9
PP	Mean	168.5	52.8	43.3*	18.0	110.1	34.0*	31.3*
	SD	± 5.2	± 1.7	± 2.4	± 4.7	± 13.2	± 4.0	± 3.2
CP	Mean	168.6	53.7**	45.8**	14.6**	114.8*	35.9*	34.5**
	SD	± 5.3	± 1.7	± 2.8	± 5.1	± 14.3	± 4.7	± 4.2

Data were presented as mean ± SD, N=30. ANOVA followed by multiple two-tail t-tests with Bonferroni adjustment. Data were significantly different from each other *P<0.05, when compared with TP, **P<0.05, when compared with PP. LBM= lean body mass, BST= back strength, GSTR= grip strength right hand, GSTL= grip strength left hand.

Effect of training was noted on heart rate during sub-maximal exercise, maximal exercise as well as recovery. Heart rate recorded during sub-maximal exercise decreased significantly (P<0.05) after both 6 wks and 12 wks of training. Significant reduction (P<0.05) in heart rate during rest

and maximal exercise were also noted after 12 wks following the training. Significant reduction ($P<0.05$) in heart rate was also noted during 2nd and 3rd min of recovery period following the 12 wks of training.

However, no significant change was noted in heart rate recorded during 1st min of recovery after an exhaustive exercise on treadmill following the training (Table 2).

Table 2. Effect of training on heart rate responses during sub-maximal exercise, maximal exercise and recoveries on young Indian soccer players

Groups		RHR (beats/min)	HR1 (beats/min)	HR2 (beats/min)	HRM (beats/min)	HRR1 (beats/min)	HRR2 (beats/min)	HRR3(kg) (beats/min)
TP	Mean	69.0	129.0	141.7	185.8	162.7	139.1	123.7
	SD	± 2.7	±12.4	±10.6	±3.7	±7.8	±9.1	±9.9
PP	Mean	68.5	125.5*	144.1*	186.9	161.3	137.3	120.4
	SD	± 2.3	±13.0	±11.1	±5.6	±9.0	±10.1	±11.1
CP	Mean	66.0*	120.6*	138.7*	183.3*#	158.3	133.0*	117.7*
	SD	±2.7	±13.6	±11.2	±5.1	±9.9	±12.3	±11.5

Data were presented as mean ± SD, N=30. ANOVA followed by multiple two-tail t-tests with Bonferroni adjustment. Data were significantly different from each other * $P<0.05$, when compared with TP, # $P<0.05$, when compared with PP. RHR= resting heart rate, HR1= sub-maximal heart rate 1st min, HR2= sub-maximal heart rate 2nd min, HR_{max}= maximal heart rate, HRR1= recovery heart rate 1st min, HRR2= recovery heart rate 2nd min, HRR3= recovery heart rate 3rd min

Further, significant increase ($P<0.05$) in aerobic capacity (VO_{2max}) was noted after 12 wks of training. In addition, anaerobic power was also increased significantly ($P<0.05$) after 6 wks and 12 wks of training among the players (Fig 1).

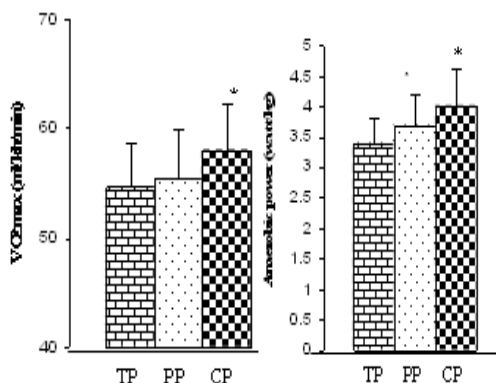


Figure 1. Effect of training on maximal aerobic capacity and anaerobic power of young Indian soccer players.

Data were presented as mean ± SD, N=30. ANOVA followed by multiple two-tail t-tests with Bonferroni adjustment. Data were significantly different from each other * $P<0.05$ when compared to TP, # $P<0.05$ when compared to PP, TP= transition phase, PP= preparatory phase, CP= competitive phase.

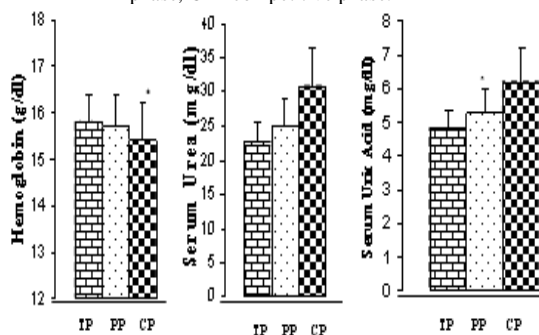


Figure 2. Effect of training on hemoglobin, serum urea and uric acid on young soccer players.

Data were presented as mean ± SD, N=30. ANOVA followed by multiple two-tail t-tests with Bonferroni adjustment. Data were significantly different from each other * $P<0.05$ when compared to TP, # $P<0.05$ when compared to PP. TP= transition phase, PP= preparatory phase, CP= competitive phase

Biochemical parameters including haemoglobin, urea, uric acid, total cholesterol, triglyceride, HDLC and LDLC were noted. Results showed a significant reduction ($P<0.05$) in haemoglobin concentration following 12 wks of training. On the other hand a significant increase ($P<0.05$) in blood urea and uric acid were noted after both 6 wks and 12 wks of training (Fig 2). Further, significant

elevation ($P<0.05$) was noted in blood level of HDLC after the training. Moreover, significantly lower level ($P<0.05$) of triglyceride was also noted after 12 wks of training. On the contrary, significant reduction ($P<0.05$) in total cholesterol, LDLC, the ratio of TC/HDLC and LDLC/HDLC were noted after both the 6wks and 12 wks of training (Table 3).

Table 3. Effect of training on lipids and lipoproteins profile of young Indian soccer players.

Groups	TC(mg/dl)	TG(mg/dl)	HDLC(mg/dl)	LDLC(mg/dl)	TC/HDLC	LDLC/HDLC	
TP	Mean	167.3	93.5	38.7	113.3	4.4	3.0
	SD	± 26.5	±19.3	±5.3	±25.8	±1.0	±0.9
PP	Mean	154.7*	85.8	46.5*	91.1*	3.4*	2.1*
	SD	± 15.8	±23.3	±8.9	±15.2	±0.7	±0.6
CP	Mean	147.8*#	76.8*	48.5*	80.7*#	3.1*#	1.7*#
	SD	±10.1	±25.3	±7.2	±10.8	±0.4	±0.4

Data were presented as mean ± SD, N=30. ANOVA followed by multiple two-tail t-tests with Bonferroni adjustment. Data were significantly different from each other $^*P<0.05$, when compared with TP, $^{\#}P<0.05$, when compared with PP. 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 suitable physique has an importance to achieve success in particular sports. The measurement of height and weight has some importance in selecting sports personal (Beunen and Malina, 1988; Beunen et al., 1997). 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. This appraisal provides an important baseline to develop an effective training programme. 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 (Franks et al., 1999). Stature and body mass have significant impact on elite soccer teams (Reilly et al., 2000a). Tall players have an advantage in playing positions such as goalkeeper, forward and defense. Body mass come into play since soccer is a body contact game. Heavy weight (not over weight) players get an advantage in defense. However, a standard body mass is required for every playing positions. The present study showed no significant change in stature among the players after the training. This may be due to short duration of training. However, significant increase in body mass was noted after 12 weeks of training. The percentage of body fat plays an important role for the assessment of physical fitness of the players (Sergej, 2003). Increase in

body fat can reduce the aerobic and anaerobic fitness (*Powers and Howley, 1997*). Present study showed a decrease in body fat in the young players. Aerobic training increases the fat utilisation during exercise, which may be the cause of the reduced fat level after training. Therefore, a low level of body fat as well as an increase in fat free body mass plays a key role in keeping physical fitness.

Many activities in soccer are forceful and explosive (e. g. tackling, jumping, kicking, 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 soccer player to have a high muscular strength, which also diminishes the risk of injury (*Fleck and Falkel, 1986; Grace, 1985*). The results of the present study showed an increase in back and grip strength after the training. The muscular strength of soccer players appears to be related to the position in the team. In a study of top-class Danish players, muscular strength was lowest for the midfield players than fullbacks, goalkeepers, forwards and central defenders (*Reilly et al., 2000a*). Strength of the back muscles plays a key role of fitness among the soccer players, as kicking and passing the ball are part of the game (*Malina et al., 2000; Manna et al., 2002; Wisloff et al., 1998*). Therefore, the game demands for high level of back strength. Moreover, strength of grips also has significant impact on the performance of the soccer players, which is needed for throwing, catching or fisting the ball (goal keeping). Responses to strength training are also thought to be small in the prepubescent child (*Bangsbo, 1994*). Until testosterone increases in boys at the time of the adolescent growth spurt, muscle mass remains below the percentage

of total body weight observed in adults. Strength gains pre-puberty are mainly due to improved neuromuscular coordination. The percentage muscle mass increases after sexual maturation as muscle development are stimulated by androgenic hormones. Increasing strength gains also accompany the rise in testosterone (*Round et al., 1999*).

Heart rate increases with an increase in work intensity and shows linear relationship with work rate (*Astrand and Rodhal, 1970*). In the present study significant reductions in heart rates during rest, sub maximal and maximal exercise was noted with the advancement of 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 times running with the ball and some times without 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 (*Powers and Howley, 1997*). 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 (*Astrand and Rodhal, 1970*).

Present study showed an increase in VO_{2max} after the training. In the young players increase in VO_{2max} with training are quite noticeable (*Reilly, 1996*). The maximum aerobic capacity for elite male players has been determined in several

studies, with mean values between 56 and 69 ml/kg/min having been reported (Reilly, 1996). Based on results obtained from elite Danish players, full backs and midfield players had the highest values and goalkeepers and central defenders the lowest. Players in a top Norwegian team had higher VO_{2max} values than that player from lower ranked team playing in the same league (67.6 vs. 59.9 ml/kg/min) (Withers et al., 1977). On the other hand, in a study of top-class Danish players, no difference in VO_{2max} was observed between regular and non-regular first-team players (Bar-Or, 1988). Nevertheless, the consistent observation of mean VO_{2max} values exceeding 60 ml/kg/min in elite teams suggests the existence of a threshold below which an individual player is unlikely to perform successfully in top-class soccer (Reilly, 1990). An earlier study reported that the VO_{2max} of young elite Danish players was as high as that of older professionals when expressed relative to body mass (Bar-Or, 1988).

In the present study significant increase in anaerobic power was noted after the training. It has been seen that post pubertal increase in physical and physiological parameters are related to increasing level of testosterone (Round et al., 1999). 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. Although mean power output over 30s on a cycle-ergometer has been used to evaluate the maximal performance of soccer players during short term exercise and thus, indirectly, their anaerobic power (Care et al., 1970; Inbar et al., 1996; Reilly et al., 2000a). Another study reported that soccer players had values about 20% higher than basketball

players, walkers and runners (Witters et al., 1977). Similarly, it has been observed that elite Hungarian soccer players had a 16-30% higher anaerobic power than an age-matched control group. It would appear, therefore, that a high anaerobic power is desirable for success in top-class soccer (Apor, 1988). This capability is reflected in the higher values for anaerobic capacity among goalkeepers, central defenders and strikers observed in English League players (Reilly et al., 1990). In children, anaerobic power is less well developed than adults (Bar-Or and Unnithan, 1994). Anaerobic power increases progressively during maturation until reaching that of adults after the teenage years.

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. Moreover, hemoglobin represents the iron status of the body (Beard and Tobin, 2000). 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 (Bar-Or and Unnithan, 1994). Dill and associates (1974) found hemoglobin concentration to be 4% lower in highly trained runners than in controls. Another study showed that the total amount of hemoglobin rather than its concentration in the blood is the determining factor for reaching a maximal VO_2 (Kanstrup and Ekblom, 1984).

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 (Urhausen and

Kindermann, 2002). The main end product of protein metabolism is urea. Prolonged exercises have been shown to cause increased urea concentration in the blood, liver, skeletal muscles, urine, and sweat (Carraro et al., 1993; Cerny, 1975). Determination of serum urea and uric acid used as indicators of over training (Urhausen and Kindermann, 2002). Therefore, monitoring of exercise stress through different biochemical parameters including serum urea and uric acid become common practice (Fry et al., 1991). The results of the present study indicated that 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, significantly higher level of HDLC was observed after the training among the players. Regular participation in physical activity is associated with lower plasma level of cholesterol, triglyceride and LDLC (Durstine and Haskell, 1994). 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

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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 LDLC (Berg et al., 1994; Durstine and Haskell, 1994). A high ratio of HDLC to LDLC, is reduced the likelihood of the development of arteriosclerosis (Berg et al., 1994; Durstine and Haskell, 1994). Evidence has been collected that endurance training results in a decrease of total cholesterol and LDLC levels and an increase of HDLC concentration (Berg et al., 1994; Durstine and Haskell, 1994). Similar observation was noted in the present study.

Conclusion

It may be concluded that these changes are due to participating in an increasing number of competitions, advancement in training and awareness in the players. It may be stated that training induced changes in different physical and physiological parameters after puberty are androgen dependent. Nutritional manipulation from the young age may help the growth and development of the players. Since, the data on young soccer players in India are limited; therefore, the present study may provide a useful database to the coaches to develop their training program.

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