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Effect of Training on Morphological, Physiological and Biochemical Variables of U-19 Soccer Players

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Effect of Training on Morphological, Physiological and Biochemical Variables of U-19 Soccer Players

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A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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Key words: *body fat, VO_{2max}, anaerobic power, strength, lipid profile, soccer*

Abstract

Background: *The purpose of the study was to find out the effect of training on selected morphological, physiological and biochemical variables in soccer players under 19 years of age.*

Material/Methods: *A total of 30 Indian male soccer players under 19 years of age (age: 16.00–18.99 yr) volunteered for this study. The training sessions were divided into 2 phases (i) Preparatory Phase (PP, 8 weeks) and (ii) Competitive Phase (CP, 4 weeks). The training programme consisted of aerobic, anaerobic and skill development, and was completed 4 hrs/day; 5 days/week. Selected morphological, physiological and biochemical variables were measured at zero level (baseline data, BD) and at the end of PP and CP.*

Results: *A significant increase ($P<0.05$) in lean body mass, VO_{2max}, anaerobic power, grip and back strength, urea and uric acid levels; and a decrease ($P<0.05$) in percentage of body fat, haemoglobin, total cholesterol, and LDL-C levels have been noted in PP and CP when compared to BD. However, no significant change was noted in stature, body mass, maximal heart rate, triglyceride and HDL-C levels of the players after the training.*

Conclusions: *This study would provide useful information for training and selection of soccer players of under-19-year-old groups.*

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Introduction

Soccer (football) is unarguably the world's most popular sport. To achieve the best possible performance, training has to be formulated according to the principles of periodization [1]. The training-induced changes observed in various morphological, physiological and biochemical parameters can be attributed to appropriate load dynamics [2, 3]. Physique and body composition have an important role for playing soccer [4]. Since soccer is a physical contact sport and lots of movements and skills are involved in playing the game, a high level of physical demand is required for match play [2, 3]. As the players have to cover a big area in the ground during attack and defence, the game demands high aerobic fitness [3, 5]. A high number of accelerations and decelerations, associated with a large number of changes in the direction of play create an additional load to the muscles of soccer players, which indicates a high need for both the aerobic and anaerobic energy delivery pathways [3, 5, 6]. Moreover, power and strength, which are required during sprinting and in execution of various skills with the ball, have a great impact on the game [2, 3].

Oxygen is transported to muscles primarily by haemoglobin [7]. During aerobic exercise the demand for oxygen increases at the working muscle, so an optimum level of haemoglobin is required to perform at the highest level with high intensity. As soccer performance depends very much on the aerobic component of an athlete, the players need to maintain a normal haemoglobin level to optimise performance. The serum level of urea and uric acid are sometimes used for assessment of training related stress [8]. During soccer 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 the use of cholesterol as a component, in conjunction with phospholipids of cellular membranes or in the synthesis of steroid hormones [9, 10]. Elevated plasma cholesterol concentrations have been implicated in the development of coronary artery disease (CAD) [9, 10]. Regular monitoring of this health related variables of soccer players can provide valuable information about their health, metabolic and cardiovascular status.

This study has been focused on the soccer players as the game is the most popular and played all over the world. The morphological, physiological and biochemical variables have a important role for the evaluation of training and for assessment of the players' health as well as their metabolic and cardiovascular status. There are insufficient studies in India on this aspect particularly among soccer players under 19 years of age. In view of the above, the present study has been designed.

Material and Methods

Subjects and Training

A total of 30 Indian males under 19 years of age (U-19, age: 16.00–18.99 yr, 17.7 ± 0.5 yr) regularly playing competitive soccer for the last 4–7 years volunteered for this study. The sportsmen were selected from a training camp at Sports Authority of India.

The players went through a training programme after taking the base line data (BD, zero level). The training sessions were divided into 2 phases: (i) Preparatory Phase (PP, 8 weeks), and (ii) Competitive Phase (CP, 4 weeks). The volume and intensities of the training components varied in each phase of training. In the preparatory phase, the volume and intensity of training gradually increased. In the competitive phase the training volume and intensity was changed according to the competition schedule. At the same time highly specified training related to soccer, practice matches and competition matches play were followed in the competitive phase. The players generally completed an average of 2 hours of training in morning sessions, which was mostly performed to improve the players' physical fitness. In the evening sessions 2 hours of technical and tactical training was given, including dribbling, tackle, set up movements, penalty corner, penalty shoot out, match practice, etc. The training sessions were conducted 5 days/week, according to the requirement of the game and the competitive demand. The training schedule, type of training, volume and intensity is shown in Table 1.

Tab. 1. General training schedule for U-19 Soccer Players

Athlete’s name	Training objectives															
	Performance		Test/Standards		Physical preparation			Technical preparation			Tactical preparation		Psychological preparation			
Competition type	Domestic											x x	x	x		x
Periodization	Training phase	Phase		Zero Level	Preparatory								Competitive			
		Sub-phase		Baseline	General preparation				Specific preparation				PC	Competition		
	Strength			-	AA			Maximal Strength					Power			
	Endurance			-	Aerobic			Anaerobic			Ergogenesis					
	Speed			-	Specific high				Specific							
	Skill Acquisition			-	Foundation			Advanced			Stimulation					
	Macro cycles			-	1				2				3		4	
	Micro cycles			-	1	2	3	4	5	6	7	8	9	10	11	12
Peaking index				-	4				4				3	2		
Testing dates				x								x				x
		%														
Training factors	Volume	100	1	-	80-90%				70-90%				70%	60-70%		
	Intensity	90	2	-	70-80%				80-90%				80%	80-90%		
	Peaking	80	3	-	70-75%								80%	>90%		
	Phys prep	70	4	-	50-55%				40-45%				30%	30%		
	Tech prep	60	5	-	40-45%				40-45%				35%	35%		
	Tact prep	50	Peaking	-	10%				10%				35%	35%		
	Psych prep	40		-					10%				20%	30-35%		
		30														
		20														
		10														

The selected morphological, 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 ± 1ºC, with relative humidity of 60–65%. The subjects were informed about possible complications of the study, and they gave their consent. The study was conducted at Sports Authority of India and was approved of by the Ethical Committee of the Institute.

Measurement of Morphological Variables

Body mass was measured with an accurately calibrated electronic scale (Seca Alpha 770, UK) to the nearest 0.1 kg, and the stature with a stadiometer (Seca 220, UK) recorded to the nearest 0.5 cm [11]. Body density was estimated from the sum of the skin-folds based on the standard procedure [12]. The skin fold measurement was taken from four different sides of the body (biceps, triceps, sub-scapular and suprailiac) using the skin fold calliper (Holtain Limited, UK) on the right side of the body:

$$BD = 1.1620 - 0.0630 \log (\text{biceps} + \text{triceps} + \text{subscapular} + \text{suprailliac})$$

The estimated percentage body fat was calculated using standard equation [13]:

$$\text{Body fat (\%)} = (495 / \text{Body density}) - 450$$

Lean body mass (LBM) was calculated by subtracting fat mass from total body mass [13]:

$$\text{Fat mass (kg)} = [\text{Body mass (kg)} \times \text{Body fat (\%)}] / 100$$

$$\text{LBM (kg)} = \text{Body mass} - \text{Fat mass}$$

Measurement of Physiological Variables

Determination of maximum oxygen consumption (VO_{2max}) and heart rates

The direct assessment of maximal aerobic capacity was achieved using a metabolic analyzer (Oxycon Champion, Jaeger, Germany) and a treadmill (Jaeger LE 500; Jaeger, Germany). Subjects were fitted with a face mask which was connected to an automated gas analyzer. This analyzer sampled the expired air containing oxygen and carbon dioxide, and through a series of calculations, oxygen consumption was determined [14]. The subject was instructed to avoid heavy food intake and exercise at least 2 hrs before the treadmill test. The treadmill was attached to a computerized metabolic analyzer. The detailed procedure of the test was explained to the subjects and the demonstration of the test was shown to them. Subjects were given a trial run on a treadmill at 0% gradient and at 4km · h^{-1}, 5km · h^{-1}, 6km · h^{-1}, and 8km · h^{-1} for 2 minutes at each speed, with the face mask attached to the mouth-piece. Then the subject was asked to stand on the treadmill with the face mask attached to the mouth-piece, while the treadmill was stationary. Expired gases were sampled breath-by-breath and measured from a mixing chamber using a computerized metabolic analyzer. The heart rate, oxygen consumption, carbon dioxide production, pulmonary ventilation and respiratory quotient (RQ) were recorded while the subject was standing on the treadmill. The initial speed and the inclination of the treadmill were 8km · h^{-1} and 2% respectively. The speed was increased by 2km · h^{-1} every 2 minutes, until volitional exhaustion (RQ>1.0). Oxygen consumption, heart rate, respiratory quotient (RQ) were monitored in every 30 seconds. When the subject’s heart rate levelled off, prior to the final exercise intensity at the value of at least 95% of the predicted maximum heart rate and his respiratory exchange ratio was greater than 1.0, the observed VO_2 was considered as VO_{2max}. During recovery the treadmill speed was gradually slowed down and stopped, and all the above physiological variables were monitored. The heart rate during exercise and recovery was also measured using Sport Tester (Polar, Finland). The Sports Tester can measure heart rate in 5 sec. intervals. The first minute recovery heart rate was recorded one minute after the cessation of exercise.

Measurement of anaerobic power

The Wingate Anaerobic Test (WANT) was performed using a cycle ergometer (Jaeger LE 900; Jaeger, Germany) following a standard methodology [15]. The subject was instructed to avoid heavy food intake and exercise at least 2 hrs before the test. The detailed procedure of the test was explained to the subjects and the demonstration of the test was shown to them. The subject was asked to follow the instructions of the investigator during the experiment. The subject was given a trial on cycle ergometer. The test requires the subject to pedal a mechanically braked bicycle ergometer for 30 seconds at an "all out" pace. The individual is advised to complete a warm-up for 3–5 minutes followed by a recovery cool down for 1–2 minutes. On commencing the test (usually by a verbal signal from the tester), the individual pedalled "all out" with no resistance. Within 3 seconds, the predetermined fixed resistance of 0.075 kg per kg body mass was applied to the flywheel and the athlete continued to pedal “all out” for 30 seconds while the load remained through out the test. A computerized counter was used to record revolutions of the flywheel in 5-second intervals, although the actual test was performed for 30 seconds. Anaerobic power was measured using the software supplied by Jaeger, Germany.

Measurement of back and grip strength

The back and grip dynamometers (Senoh, Japan) were used to record the strength of the back and grip muscles following a standard method [11]. For measurements of back strength, one hand of the subject gripped over and the other under the bar. The hands were spread to the width of shoulders. The trunk was flexed only slightly forward (10°–15°) at the hip joints. The body weight was balanced on the feet, which were placed about 15 cm apart. The knees were kept straight throughout the lift. The lift was performed steadily upwards, without jerking. The subjects were not allowed to lean backwards on the heels. It was ensured that the back was almost straight at the end of the lift. For measurement of grip strength the dryness of the hand and the instrument were ensured. The tester set the pointer to zero and placed the dynamometer in the subject's hand, with the dial against the palm and the larger (concave) pressing edge in the "heel" of the palm. The posture and positioning of the subjects tested were according to the standard method [11]. The data was obtained with the elbow at 90° flexion, shoulder at 0° flexion and wrist between 0° and 15° of ulnar and radial deviation. The subject squeezed sharply and steadily as much as possible, making certain that no part of the arm touched the body. For both back and grip strength test three trials were allowed with an interval of two minutes. The test was repeated in case any other deviation from proper procedure was noted. The highest reading of the three trials was recorded in kilograms.

Measurement of Biochemical Variables

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 by 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 the enzymatic method. Low-density lipoprotein cholesterol (LDL-C) was indirectly assessed following a standard equation [21].

Statistical Analysis

All the values of morphological, physiological and biochemical variables were expressed as mean and standard deviation (SD). Analysis of Variance (ANOVA) with repeated measures followed by multiple comparison (Post Hoc) tests was performed to find out the significant difference in selected morphological, physiological and biochemical variables in different training phases. Pearson's correlation coefficient was performed to find out the relationship between the players' 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

Effect of Training on Morphological Characteristics of U-19 Soccer Players

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

Tab. 2. Effect of training on morphological characteristics of U-19 soccer players

Parameters	F ratio (df)	BD	PP	CP
Stature (cm)	0.22^{NS} (2, 89)	171.7 ± 4.7	171.7^{NS} ± 4.7	171.7^{NS} ± 4.7
Body Mass (kg)	2.65^{NS} (2, 89)	58.9 ± 4.9	57.7^{NS} ± 4.6	57.1^{NS} ± 4.6
Body Fat (%)	4.92^{*} (2, 89)	14.3 ± 2.3	13.4^{*} ± 2.9	13.0^{*} ± 1.3
LBM (kg)	3.12^{*} (2, 89)	47.1 ± 4.1	48.3^{*} ± 4.1	48.7^{*} ± 4.4

*ANOVA followed by multiple comparison (Post Hoc) tests was performed. Each value represents mean ± SD. N= 30. $F_{.05}$ (2, 89) = 3.11. Computed using alpha = 0.05; * when compared to BD, df= degree of freedoms, NS= not significant, BD= Base Line Data, PP= Preparatory Phase, CP= Competitive Phase, LBM= lean body mass.*

Effect of Training on Physiological Characteristics of U-19 Soccer Players

In the present study, a significant increase in VO_{2max} was observed among the soccer players when comparing base line data with that of the preparatory and the competitive phases. Heart rate recorded during recovery after maximal exercise decreased significantly (P<0.05) in the preparatory and the competitive phases of training when compared to base line data. However, no significant change was observed in the players' maximal heart rate (HR_{max}) following the training programme. On the other hand, when comparing base line data with that of the preparatory and the competitive phases, a significant (P<0.05) increase in anaerobic power, back strength and grip strengths were noted among the players (Table 3).

Tab. 3. Effect of training on physiological characteristics of U-19 soccer players

Parameters	F ratio (df)	BD	PP	CP
VO_{2max} (ml kg^{-1} min^{-1})	3.15* (2, 89)	58.5 ± 2.23	60.7* ± 3.1	60.2* ± 4.2
HRmax (beats min^{-1})	0.93^{NS} (2, 89)	189.5 ± 3.5	188.0 ^{NS} ± 4.9	188.1 ^{NS} ± 5.7
RHR1 (beats min^{-1})	10.96* (2, 89)	155.8 ± 4.6	151.9* ± 3.8	151.9* ± 4.3
AP (W kg^{-1})	10.30* (2, 89)	9.3 ± 0.8	10.4* ± 1.4	10.6* ± 1.5
BST (kg)	23.98* (2, 89)	112.2 ± 4.7	114.5* ± 4.5	114.6* ± 4.9
GSTR (kg)	3.11* (2, 89)	31.2 ± 3.8	33.1* ± 3.4	33.3* ± 3.2
GSTL (kg)	4.13* (2, 89)	30.5 ± 2.8	32.2* ± 3.8	32.6* ± 3.2

*ANOVA followed by multiple comparison (Post Hoc) tests was performed. Each value represents mean ± SD. N= 30. $F_{.05}$ (2, 89) = 3.11. Computed using alpha = 0.05; * when compared to BD, df= degree of freedoms, NS= not significant, BD= Base Line Data, PP= Preparatory Phase, CP= Competitive Phase, VO_{2max} = maximal aerobic capacity, HR_{max}= maximal heart rate, HRR1= recovery heart rate 1st min, AP= anaerobic power BST= back strength, GSTR= grip strength right hand, GSTL= grip strength left hand.*

Effect of Training on Biochemical Characteristics of U-19 Soccer Players

A significant reduction (P < 0.05) in the haemoglobin level was noted in the preparatory and competitive phases when compared to the soccer players' base line data. On the other hand, a significant (P < 0.05) increase in serum urea was noted in the preparatory and competitive phases when compared to base line data of the players (Table 4). In addition, when comparing the preparatory phase with that of the competitive phase, a significant (P < 0.05) increase in the serum urea level was noted among the players. Furthermore, when comparing the 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. However, no significant change in serum uric acid level was noted in the preparatory phase when compared to base line data of the soccer players (Table 4).

Tab. 4. Effect of training on hemoglobin, urea, uric acid levels of U-19 soccer players

Parameters	F ratio (df)	BD	PP	CP
Hemoglobin (g dl^{-1})	3.12* (2, 89)	14.0 ± 0.6	13.6* ± 0.6	13.6* ± 0.6
Urea (mg dl^{-1})	8.89* (2, 89)	27.1 ± 2.7	28.0* ± 3.0	31.3$^{*\#}$ ± 2.9
Uric acid (mg dl^{-1})	39.49* (2, 89)	3.5 ± 0.5	3.9 ^{NS} ± 0.5	3.9* ± 0.6

*ANOVA followed by multiple comparison (Post Hoc) tests was performed. Each value represents mean ± SD. N= 30. $F_{.05}$ (2, 89) = 3.11. Computed using alpha = 0.05; * when compared to BD, df= degree of freedoms, NS= not significant, BD= Base Line Data, PP= Preparatory Phase, CP= Competitive Phase.*

A significant reduction (P < 0.05) in the total cholesterol level was noted in the competitive phase when compared to the players' base line data. However, when comparing base line data with that of the preparatory phases no significant change was noted in the total cholesterol level among the soccer players. In addition, a significant reduction (P < 0.05) in LDL-C level was noted in the preparatory and the competitive phases when compared to base line data of the players. However, when comparing base line data with that of the preparatory and competitive phases no significant change was noted in the triglyceride and HDLC levels among the players (Table 5).

Tab. 5. Effect of training on lipids and lipoproteins profiles of U-19 soccer players

Parameters	F ratio (df)	BD	PP	CP
TC (mg dl^{-1})	4.03^{*} (2, 89)	158.2± 5.2	156.7^{NS} ± 5.3	155.3^{*} ± 4.6
TG (mg dl^{-1})	3.11^{*} (2, 89)	64.9 ± 5.5	62.7^{NS} ± 5.7	62.2^{NS} ± 5.7
HDLC (mg dl^{-1})	3.27^{*} (2, 89)	39.2 ± 3.1	41.9^{NS} ± 2.7	42.0^{NS} ± 2.9
LDLC (mg dl^{-1})	3.11^{*} (2, 89)	102.4 ± 5.3	101.0^{*} ± 4.8	100.0^{*} ± 4.3

*ANOVA followed by multiple comparison (Post Hoc) tests was performed. Each value represents mean ± SD. N= 30. $F_{.05}$ (2, 89) = 3.11. Computed using alpha = 0.05; * when compared to BD, df= degree of freedoms, 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.*

Correlation Studies

In the present study percentage of body fat showed significant negative correlations with VO_{2max} (r= -0.57, p<0.01) and anaerobic power (r= -0.32, p<0.01) of the football players. The anaerobic power showed significant positive correlations with VO_{2max} (r= 0.52, p<0.01) and back strength (r= 0.49, p<0.01), and a negative correlation with the percentage of body fat (r= -0.32, p<0.01) of the football players. In addition, back strength showed significant positive correlations with VO_{2max} (r= 0.60, p<0.01) and anaerobic power (r= 0.49, p<0.01), and a negative correlation with percentage of body fat (r= -0.12) among the football players of the present study. The oxidative potentiality of an athlete is dependent on his haemoglobin level. In the present study, a significant (p<0.000) positive correlation in the players was observed between haemoglobin and VO_{2max} (r= 0.40). On the other hand, HDL-C showed a significant positive correlation with VO_{2max} (r= 0.3, p<0.001), anaerobic power (r= 0.24, p<0.01), and strength (r= 0.3, p<0.01) of the players.

Discussion

Body size (stature and body mass) has a significant impact on soccer teams [2, 22, 23]. Tall players are recruited for goal keepers, defenders and forward positions; however, a standard height should be maintained for midfield players. Body mass is a considerable factor in soccer since body contact is essential in this game [2, 22, 24]. In this study no significant difference was observed in the stature and body mass of the soccer players after the training programme. It may be due to short duration of the training. It has been reported that short term exercise training has no significant effect on athletes' body mass [25, 26].

The percentage of body fat plays an important role for the assessment of soccer players' physical fitness [2, 23, 24, 27]. A lean body is desirable for sports like soccer [2, 23, 24, 27]. A low-body fat may improve athletic performance by improving the strength-to-weight ratio [3, 25, 26]. Excess body fat adds to the load without contributing to the body's force-producing capacity [3, 25, 26]. A reduction (P<0.05) in percentage of body fat was noted among the players after the training. The possible reason for reduction of body fat is exercise training which increases greater utilization of fat for energetic processes [34, 35]. However, a significant increase (P<0.05) in LBM was noted in the U-19 players after the training. Similar findings were also noted by other research groups who studied soccer players and reported that percentage of body fat decreased significantly during the preparatory and competitive phase of training when compared to baseline data [3, 28]. In addition, percentage of body fat showed significant negative correlations with VO_{2max} (r= -0.57, p<0.01) and anaerobic power (r= -0.32, p<0.01) of the football players. Therefore, it can be stated that increased body fat can reduce the players' aerobic and anaerobic fitness. Soccer players can accumulate body fat in the off seasons when there is no training and lose body fat more during the preparatory phase and the competitive phase of training [25, 26]. This might be due to intensive training during the preparatory phase and a high level of performance during the competitive phase

[25, 26]. Before and after the season, during the interval most soccer players have their fat content increased, presumably owing to reduced aerobic activity along with nutritional and behavioural changes [25, 26]. It is advised to perform low intensity aerobic endurance exercise during the off seasons in order to reduce the excess accumulation of body fat during the off seasons.

The maximal oxygen uptake (VO_{2max}) is the best overall measure of aerobic power [3, 5]. Aerobic capacity certainly plays an important role in soccer and has a major influence on technical performance and tactical choices [3, 25, 26]. An increase ($P<0.05$) in relative VO_{2max} value was noted among the players in the preparatory phase and the competitive phases when compared with that of the baseline data. The increase in VO_{2max} after training may be due to an increase in the systemic a-v O_2 difference and stroke volume, when compared to senior players [25, 26]. Moreover, these changes may result from the increased volume of endurance training in the preparatory phase [25, 26]. The aerobic endurance training enhances the activity of the cardiovascular system as well as developed oxidative capacity of he skeletal muscles, and thus oxygen delivery to the working muscle is increased [25, 26]. This is accepted as the main reason for elevation of VO_{2max} after a training programme [25, 26]. A similar observation was noted by other research groups [2, 3, 6]. The extent by which VO_{2max} can change with training also depends on the starting point [25, 26]. Other than the tactical and technical aspect of the game monitoring of VO_{2max} is essential during the training phases, which help the coaches select players for competition.

Heart rate increases with an increase in work intensity and shows a linear relationship with work rate [14]. The highest rate at which the heart can beat is the maximal heart rate (HR_{max}). Quick recovery from strenuous exercise is important in soccer, which involves intermittent efforts interspersed with short rests [25, 26, 29]. The heart rate recovery curve is an excellent tool for tracking a person's progress during a training program [25, 26]. A significant decrease ($P<0.05$) in the recovery heart rate was noted among the players after training. Exercise cardio acceleration results from release of parasympathetic inhibition at low exercise intensities and from both parasympathetic inhibition and sympathetic activation at moderate intensities [25, 26]. Nevertheless, parasympathetic activation is considered to be the main mechanism underlying exponential cardio deceleration after exercise [25, 26]. On the other hand, no significant change was noted in HR_{max} of the players after the training. This may be due to shorter duration of the training. It has been seen that short term exercise has no significant effect on HR_{max} [25, 26]. The results of the present study suggest that the strain on the circulatory system while playing soccer is relatively high. Exercising at this intensity should provide a good training stimulus, on condition that such participation is frequent enough. Therefore, heart rate monitoring is essential during the training seasons, which also provide a data base for coaches to select players.

The game of soccer demands high anaerobic power as quick acceleration and deceleration are part of the game [2, 3]. Although most 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 [2, 3]. High anaerobic power is essential for such activities [2, 3]. Thus high anaerobic power helps the players to develop sprint quality [2, 3]. Anaerobic power represents the highest rate of anaerobic energy released [25, 26]. On the other hand, strength is the central component of a soccer training program [2, 3]. Strength of the back muscles plays a key role of fitness among soccer players, as kicking, passing, changing pace etc. are part of the game [2, 3]. Therefore, the game demands a high level of back strength. Furthermore, strength of grip muscle also has a significant impact on the performance of soccer players, which is needed for throw-in, catching or fisting the ball (goal keeping) [2, 3]. A significant increase ($P<0.05$) in anaerobic power and strength was noted among the soccer players after training. This may be due to training, as particularly resistance and strength training increases the gain in anaerobic power and strength of the athletes. A similar observation has been made by many researchers [2, 3, 30]. The anaerobic power showed significant positive correlations with VO_{2max} ($r= 0.52$, $p<0.01$) and back strength ($r= 0.49$, $p<0.01$), and a negative correlation with percentage of body fat ($r= -0.32$, $p<0.01$) of the football players. In addition, back strength showed significant positive correlations with VO_{2max} ($r= 0.60$, $p<0.01$) and anaerobic power ($r= 0.49$, $p<0.01$), and a negative correlation with percentage of body fat (r= -0.12) among the football players of the present study. Therefore, it is suggested that high aerobic and anaerobic fitness increases the strength parameters and reduces the body fat content of the players. Studies on soccer players reported that the strength and power increased after training [2, 3]. Monitoring power and strength at regular intervals is essential during the training seasons, which help in selection of players for competitions.

Oxidative potentiality of an athlete is dependent on his haemoglobin level [25, 26]. An increase in VO_{2max} demands a higher rate of oxygen supply [25, 26]. Oxygen is transported to muscle primarily by haemoglobin, and it is suggested that haemoglobin mass and/or concentration is related to VO_{2max} [31]. During the zero level the training load was zero. Then the training load was increased in the preparatory phase and the competitive phase; therefore, in the preparatory phase and competitive phase reduced ($P<0.05$) haemoglobin level was observed when compared to baseline data. Moreover, as the performance level increased in the competitive phase, the decline in the haemoglobin level became more prominent when compared with the baseline data. Similar observations have been noted by many researchers in their recent studies [31]. The decline in the haemoglobin level may be due to haemolysis [32]. In addition, exercise training induced reduction in haemoglobin concentration also may be due to haemodilution, which is a common physiological effect of endurance training and also exists among well-trained athletes due to increased plasma volume [31, 33]. The oxidative potentiality of an athlete is dependent on his haemoglobin level. In the present study, a significant ($p<0.000$) positive correlation was observed between haemoglobin and VO_{2max} (r=0.40) in the players. As the haemoglobin level has a relation with VO_{2max}, an optimum level of haemoglobin is required for better performance.

The present study showed that the level of serum urea and uric acid increased ($P<0.05$) after training among the players. A higher urea and uric acid level was noted in the competitive phase, when the performance level is the highest. It may be suggested that an increased level of urea and uric acid may be due to an increased intensity of training [8]. Determination of serum urea and uric acid is used as indicators of overtraining [8]. A recent study suggested that serum uric acid scavenges OH^- radicals, and there is evidence that it may be an important biological scavenger against free radicals in human plasma and in skeletal muscles during and after acute hard exercise [34]. Regular monitoring of serum urea and uric acid levels can indicate a 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. Therefore, these parameters may be used to assess the training load imposed on the players.

Lipids and lipoprotein profile indicate an athlete's cardiovascular and metabolic status [9, 10]. Activity levels have a significant impact on athletes' lipids and lipoprotein levels [9, 10]. As the performance level increased during the preparatory phase and further to the competitive phase the level of total cholesterol and LDL-C gradually decreased ($P<0.05$). It indicates that as the training load and performance level increased, the level of total cholesterol and LDL-C gradually decreased. The possible reason for the reduction in total cholesterol and LDL-C is exercise training [9, 10, 26]. However, no significant change was noted in the triglyceride and HDL-C level after the exercise. This may be due to the short duration of the training or improper optimization of the training load. Our findings are supported by observations of other researchers in their recent studies [9, 10, 35]. Cross-sectional studies also reported an increase in HDL-C level and a decrease in triglyceride level after exercise [9, 35]. A recent study showed a significant increase in HDL-C level and a decrease in LDL-C level, with no change in triglyceride after 9 weeks of training [36]. Another study reported that 4 weeks of aerobic exercise training significantly decreased the levels of total cholesterol, LDL-C, and increased HDL-C [10]. HDL-C showed a significant positive correlation with VO_{2max} (r= 0.3, $p<0.001$), anaerobic power (r= 0.24, $p<0.01$), and strength (r= 0.3, $p<0.01$) of the players of the present study. This indicates that an increase in aerobic and anaerobic fitness increases the HDL-C level of the players. Therefore, regular monitoring of lipids and lipoproteins profiles of the soccer players is essential to optimize their health status, which has direct effect on the players' performance.

Conclusion

Training effects were reflected in various parameters, such as body fat, aerobic capacity, anaerobic power, strength, haemoglobin, urea, uric acid, and lipid profile of the soccer players. These profiles should be taken into consideration while administering training to the players. As the studies on soccer 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 soccer players particularly of the under 19-year-old group. This would enable the coaches to assess an athlete's current status 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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