

# Effect of Training on Selected Biochemical Variables of Elite Male Swimmers

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**Abstract** The aim of the present study was to find out the effect of training on biochemical variables of elite male swimmers. A total of 60 Indian elite male swimmers (age:  $17.33 \pm 1.47$  yrs; height:  $173.08 \pm 5.80$  cm; body mass:  $68.11 \pm 5.02$  kg) who regularly participate in competitive swimming volunteered for this study. A well-designed training program for the swimmers was employed for 12 weeks. The training sessions were divided into 2 phases (a) Preparatory Phase (PP, 8 weeks) and (b) Competitive Phase (CP, 4 weeks). Each phase was further subdivided into macro cycles and micro cycles, and were completed 4 hr/d; 5 d/wk. Selected variables were measured at zero level (baseline data, BD) and at the end of preparatory phase (PP) and competitive phase (CP) of training. A significant increase ( $P < 0.05$ ) in serum urea, uric acid, high density lipoprotein cholesterol (HDL-C) was observed after training. On the other hand, a significant reduction ( $P < 0.05$ ) in resting and peak blood lactate, hemoglobin, total cholesterol (TC), triglyceride (TG) and low density lipoprotein cholesterol (LDL-C), TC/HDL and LDL/HDL were noted after the conclusion of training. The training program was effective for improving selected biochemical parameters for swimmers, and may be employed for monitoring training.

**Keywords:** blood lactate, hemoglobin, uric acid, lipid profile, training

## 1. Introduction

Swimming is one of the most exciting of the Olympic sports. The tournament competitive schedules of top swimmers and their training programs are arguably more severe than in any other sports. Training can improve the performance of the swimmers [1]. To achieve the best possible performance, the training has to be designed according to the principles of periodization [1]. The training induced changes observed in various biochemical variables can be attributed to appropriate load dynamics. 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 [1].

Biochemical parameters like blood lactate, hemoglobin, urea, uric acid and lipid profiles have an advantage in regulating the training load. Assessment of blood lactate levels during pre and immediately post exercise can be useful to determine the lactate threshold level during training and competition [2]. Hemoglobin represents the iron status of the body [2,3]. Oxygen is transported to muscle primarily by hemoglobin [2,3]. During aerobic exercise the demand of oxygen increases at the working muscle, so an optimum level of hemoglobin is required to perform at the highest level with high intensity. As swimming performance depend much on the aerobic component of the athlete, therefore the players need to maintain normal hemoglobin level to optimize

performance. The serum level of urea and uric acid are used for assessment of training related stress [4]. During the training these parameters may be evaluated at regular intervals to assess the training load imposed on the athlete [4]. In addition, the urea and uric acid accumulation is most frequently used as a measure of protein catabolism and degradation of adenonucleotides [5,6]. Lipids have important beneficial biological functions that include the use of triglycerides, for energy production or as stored fat in adipose tissue and use of cholesterol as a component, in conjunction with phospholipids of cellular membranes or in the synthesis of steroid hormones [7,8]. Elevated plasma cholesterol concentrations have been implicated in the development of coronary artery disease (CAD) [7,8,9,10]. The primary function of high density lipoprotein cholesterol (HDL-C) is to serve as the cholesterol acceptor in the reverse transport and excretion of cholesterol [9,10]. On the other hand low density lipoprotein cholesterol (LDL-C) is directly associated with cholesterol [7,8,9,10]. It has been reported that LDL-C has the greatest correlation to severity of coronary atherosclerosis [7,8,9,10]. Therefore, monitoring of lipid profile in athletes can provide valuable information about their metabolic and cardiovascular status.

The present study has been focused on elite swimmers as the sport is popular throughout the world, but limited studies are available on swimmers. Although some of the studies reviewed on the physiological characteristics and the training aspect of the swimmers at the international level [7], limited studies have been reported on the biochemical parameters of Indian swimmers. Considering

the current literature, a study was undertaken to investigate the effect of training on specific biochemical variables of elite male swimmers.

## 2. Method

### 2.1. Subjects

A total of 60 Indian elite male swimmers (age:  $17.33 \pm 1.47$  yrs; height:  $173.08 \pm 5.80$  cm; body mass:  $68.11 \pm 5.02$ kg) who regularly participate in competitive swimming volunteered for this study. The subjects were informed about the possible complications of the study and gave their consent. The study was conducted at Sports Authority of India (SAI) and was approved by the Ethical Committee of the Institute. The selected biochemical variables were measured in the laboratory at the beginning of the training (baseline data, BD) and at the end of Preparatory (PP) and Competitive Phase (CP). Each test was scheduled at the same time of day ( $\pm 1$  hr) in order to minimize the effect of diurnal variation. All the experiments were performed at  $25 \pm 1^\circ\text{C}$ , with relative humidity of 60 - 65 %.

### 2.2. Training

A well-designed training program for swimmers was employed for 12 weeks. The training sessions were divided into 2 phases (a) Preparatory Phase (PP, 8 weeks) and (b) Competitive Phase (CP, 4 weeks). Each phase was further subdivided into macro cycles and micro cycles. The volume and intensities of the training components 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. At the same time highly specified training related to swimming events, mock competition, and actual competition was followed in the competitive phase. The swimmers generally completed an average of 2 hrs of training in morning and 2 hrs in the evening sessions, which were followed 5d/wk, according to the requirement of the game and competitive demand. The training schedule, type of training, volume and intensity is shown in [Table 1](#).

**Table 1. General training schedule for the elite male swimmers**

| Training             | Transition phase | Preparatory phase | Competitive phase |
|----------------------|------------------|-------------------|-------------------|
| Continuous training  | Low              | High              | Low               |
| Interval training    | Low              | High              | Maintenance       |
| Strength training    | Low              | High              | Low               |
| Power training       | Low              | High              | Maintenance       |
| Speed training       | Low              | High              | Maintenance       |
| Flexibility training | Low              | High              | High              |
| Skill training       | Low              | High              | Maintenance       |

### 2.3. Measurement of Biochemical Variables

#### 2.3.1. Estimation of Blood Lactate

Arterialized samples were obtained from fingertip and under ideal conditions pre exercise and immediately post exercise for estimation of resting and peak blood lactate levels. Blood samples were analyzed immediately by a lactate analyzer (YSI Sport 1500, USA) using the YSI lactate kit [11]. Special care was taken to prevent contamination from sweat and to enhance rapid circulation.

#### 2.3.2. Estimation of Hemoglobin, Urea, Uric Acid, Lipids and Lipoproteins

A 5ml of venous blood was drawn from an antecubital vein after a 12 hrs fast and 24 hrs after the last bout of exercise for subsequent determination of hemoglobin (Hb), blood urea, serum uric acid, total cholesterol (TC), triglycerol (TG), high density lipoprotein-cholesterol (HDL-C) and low density lipoprotein-cholesterol (LDL-C). Haemoglobin was measured using Cyanmethaemoglobin method [12]. Blood urea [13] and serum uric acid [13] were determined calorimetrically using standard procedure. Serum total cholesterol [14], serum triglycerol [15] and HDL-C [15] were determined by enzymatic method. LDL-C was indirectly assessed following standard equation [15]. The ratio of TC and HDL-C, LDL-C and HDL-C was determined.

### 2.4. Statistical Analysis

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

## 3. Results

A significant decrease ( $P < 0.05$ ) in resting blood lactate levels and an increase in peak blood lactate levels were noted in preparatory and competitive phases when compared to base line data of the swimmers. In addition, a significant reduction ( $P < 0.05$ ) in hemoglobin level was noted among the swimmers in preparatory and competitive phases when compared to pre training condition. On the contrary, a significant elevation ( $P < 0.05$ ) in blood urea level was noted in competitive phase when compared to pre training data of the swimmers. In addition, significant increase ( $P < 0.05$ ) in serum uric acid level was observed among the swimmers in preparatory and competitive phases when compared to that of the base line data ([Table 2](#)).

The present showed, a significant elevation ( $P < 0.05$ ) in high density lipoprotein cholesterol (HDL-C) level among the swimmers in preparatory and competitive phases when compared to the data taking at beginning of the training. On the other hand, significant reduction ( $P < 0.05$ ) in total cholesterol (TC), triglyceride (TG), low density lipoprotein cholesterol (LDL-C), ratios of TC/HDL-C and LDL-C/HDL-C levels were observed among the swimmers in the preparatory and competitive phases when compared to base line data. Further, a significant ( $P < 0.05$ ) decline in TC, TC/HDL-C and LDL-

C/HDL-C levels were noted in competitive phase when compare to preparatory phase (Table 3).

**Table 2. Effect of training on blood lactate, haemoglobin, urea and uric acid levels of elite male swimmers**

| Parameters                               | BD         | PP                       | CP          |
|------------------------------------------|------------|--------------------------|-------------|
| Resting Lactate (mmol. l <sup>-1</sup> ) | 2.8 ± 0.4  | 2.3* ± 0.3               | 2.2* ± 0.5  |
| Peak lactate (mmol. l <sup>-1</sup> )    | 7.1 ± 0.4  | 6.3* ± 0.5               | 6.5* ± 0.5  |
| Hb (g. dl <sup>-1</sup> )                | 15.1 ± 0.5 | 14.7* ± 0.4              | 14.5* ± 0.4 |
| Urea (mg. dl <sup>-1</sup> )             | 28.9 ± 4.2 | 30.0 <sup>NS</sup> ± 4.0 | 32.7* ± 3.6 |
| Uric acid (mg. dl <sup>-1</sup> )        | 4.0 ± 0.7  | 4.6* ± 0.7               | 4.9* ± 0.9  |

Data presented as mean ± SD; n = 60; Computed using alpha = 0.05; \* when compared to BD, # when compared to PP. BD= base line data, PP = preparatory phase, CP = competitive phase, NS= not significant; Hb = haemoglobin

**Table 3. Effect of training on lipids and lipoproteins levels of elite male swimmers**

| Parameters                    | BD          | PP           | CP             |
|-------------------------------|-------------|--------------|----------------|
| TC (mg. dl <sup>-1</sup> )    | 167.2 ± 6.7 | 159.7* ± 5.8 | 154.2* # ± 6.3 |
| TG (mg. dl <sup>-1</sup> )    | 88.4 ± 6.3  | 82.0* ± 7.4  | 79.6* ± 5.4    |
| HDL-C (mg. dl <sup>-1</sup> ) | 34.4 ± 4.9  | 38.1* ± 5.1  | 40.4* ± 4.9    |
| LDL-C (mg. dl <sup>-1</sup> ) | 115.1 ± 6.4 | 111.0* ± 7.2 | 108.4* ± 7.1   |
| TC/HDL-C                      | 4.9 ± 0.8   | 4.2* ± 0.6   | 3.8* # ± 0.6   |
| LDL-C/HDL-C                   | 3.3 ± 0.1   | 2.9* ± 0.5   | 2.7* # ± 0.6   |

Data presented as mean ± SD; n=60; Computed using alpha = 0.05; \* when compared to BD, # when compared to PP. BD= base line data, PP= preparatory phase, CP= competitive phase, NS= not significant; TC= total cholesterol, TG= triglyceride, HDL-C= high density lipoprotein cholesterol, LDL-C= low density lipoprotein cholesterol

## 4. Discussion

During exercise of increasing intensity there is a rise in blood lactate concentration resulting from increased glycogenolysis [16,17]. This increase in blood lactate concentration has been interpreted as a reflection of the onset of hypoxia in skeletal muscles and the exercise intensity at which anaerobic metabolism generate ATP is known as the anaerobic threshold [16,17]. The velocity of swimming corresponding to a blood lactate level of 4 mmol.l<sup>-1</sup> is thought to represent a so-called anaerobic threshold exercise, and at intensity above this place stress on anaerobic metabolism. The level of exercise which produces a blood lactate concentration of 4 mmol.l<sup>-1</sup> is making a significant contribution to anaerobic metabolism. Swimming at intensities below 4 mmol.l<sup>-1</sup> can be sustained for longer periods [16,17]. In the present study, a significant decrease (P < 0.05) in resting blood lactate levels and peak blood lactate levels were noted in preparatory and competitive phases of training when compared to base line data of the swimmers. These changes might be due to differing training regimens as found by other researchers [18,19]. An appropriate session would be three sets of 6-10 repetitions of 50m with 10-30 s between repetitions and 3-5 min between sets which can produce a high peak lactate level [20]. The intense activity from large muscle masses and restricted patterns of breathing during competitive swimming, favors the involvement of anaerobic energy release with the subsequent accumulation of lactate in the blood. Improvements in lactate tolerance are especially important

in the shorter swim distances, 100 m and 200m. Improvement in lactate tolerance is related to enhanced buffering capacity, increased activity of the muscle form of lactate dehydrogenase and sensitivity to increasing metabolic acidosis. A major effect of endurance training is thought to be enhanced lactate clearance [18,19].

Hemoglobin concentration is related to VO<sub>2max</sub> of the athletes [16]. In the present study, a significant reduction (P < 0.05) in hemoglobin level was noted in preparatory and competitive phases of training when compared to base line data of the swimmers. This might be due to the effect of training. During the competitive phase training load along with the stress of competition was responsible for the declined in hemoglobin level. Studies on professional athletes showed that hemoglobin values were higher at the beginning of the competition season, and then declined in well-trained athletes [21,22]. It can be suggested that the decline in hemoglobin level might be due to haemolysis [23] and hemodilution [24] which are common physiological effects of endurance training also exist among the well trained athletes.

The blood urea and serum uric acid level has been considered as an indicator of overtraining and protein catabolism [4,6]. In this study, a significant elevation (P < 0.05) in blood urea level was noted among the swimmers in competitive phase when compared to pre training data. In addition, significant increase (P < 0.05) in serum uric acid level was observed among the swimmers in preparatory and competitive phases of training when compared to that of the base line data. The highest levels of urea and uric acid were noted in the competitive phase when the training load and stress of competition was highest. The possible reason for the increased urea and uric acid levels might be due to increase in training stimulus and increase breakdown of proteins. 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 levels in blood is an index of time to perform subsequent strenuous training sessions [4]. Similar observations have been reported by many researchers on sports participants other than swimmers [6,24].

Lipids and lipoprotein profile indicate the cardiovascular and the metabolic status of the athlete [8,25]. In the present study, a significant elevation (P < 0.05) in high density lipoprotein cholesterol (HDL-C) level was noted among the swimmers in preparatory and competitive phases of training when compared to base line data. On the other hand, significant reduction (P < 0.05) in total cholesterol (TC), triglyceride (TG), low density lipoprotein cholesterol (LDL-C), ratios of TC/HDL-C and LDL-C/HDL-C levels were observed among the swimmers in the preparatory and competitive phases of training when compared to pre training data. Further, significant (P < 0.05) decline in TC, TC/HDL-C and LDL-C/HDL-C was noted among the swimmers when comparing preparatory phase with that of the competitive phase of training. These changes might be due to training. As the training load increased from pre-training period to preparatory phase and competitive phase, the level of total cholesterol, triglyceride and LDL-C were decreased, and the level of HDL-C increased gradually. The possible reason for the reduction in total cholesterol, triglyceride and LDL-C; and elevation in HDL-C was exercise.

Especially endurance exercise increases metabolism and utilization of blood lipids and lipoprotein for energy production [8,9]. Our findings are in conformity with the observations of other researchers in their recent studies. Cross-sectional studies reported an increase in HDL-C level and decrease in triglyceride level after exercise [7,8,25]. A recent study showed significant increase in HDL-C and decrease in LDL-C level, with no change in triglyceride after 9 weeks of training [26]. Another study reported that 4 weeks of aerobic exercise training significantly decreased the levels of total cholesterol, LDL-C; and increased HDL-C [9].

## 5. Conclusions

These changes are due to participation in training as well as number of competitions. A specific swimming training program with the structure and loads described in this study was effective of improving biochemical variables such as blood lactate, hemoglobin, blood urea and serum uric acid, lipids and lipoproteins profiles of the swimmers. Regular monitoring of the biochemical variables of the swimmers is essential to optimize their general health, metabolic and cardiovascular status which has direct relation with their performance. The unique profile should be taken into consideration while administering training to the swimmers.

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