EFFECT OF SPECIFIC TRAINING PROGRAM ON SELECTED MOTOR FITNESS ANTHROPOMETRIC AND PHYSIOLOGICAL PARAMETERS OF YOUNG SWIMMERS

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Dedicated

to

My Beloved Parents, My Brothers, My Swimming Coach and Specially My Supervisor

CERTIFICATE

Certified that the thesis entitled "***Effect of Specific Training Program on Selected Motor Fitness Anthropometric and Physiological Parameters of Young Swimmers***" submitted by me for the award of the Degree of Doctor of Philosophy in Arts at Jadavpur University is based upon my work carried out under the supervision of **Prof. Sudip Sundar Das**, Department of Physical Education, Jadavpur University, Kolkata and that neither this thesis nor any part of it has been submitted before for any degree or diploma anywhere / elsewhere.

....	....
Counter signed by the Supervisor	Signature of the Candidate
Dated:	Dated:

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Dinabandhu Naskar

DECLARATION

I hereby declare that the research work on the topic of: "***Effect of Specific Training Program on Motor Fitness Anthropometric and Physiological Parameters of Young Swimmers***", is an original piece of research done by me under the supervision of Professor Sudip Sundar Das, Department of Physical Education, Jadavpur University, Kolkata, West Bengal, India. I have specified names of references from where the information has been taken. To the best of my knowledge, this thesis does not contain any part of any work without proper citation, which has been submitted for a degree or any other academic qualification at any others university in India or abroad.

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PREFACE

A radical change has been noticed in recent years in sports parlance Science and technology has taken over the task of improvement of human performance in sports. Vast change has been occurred in physique of 'the athlete, as well as equipment, surface/floor of the athletic arena have been modernised. The other most important aspect is methods of training and coaching. To match the performer with the performance appropriate and specific training make the crucial difference. To facilitate sports performance the coaches are now a-days depending on the sports science. Appropriate planning followed by scientific performance evaluation and reinforcement on the basis of the evaluation is the order of the modern-day scientific preparation of the athletes. Training has become so purposeful so specific that researchers have Identified subcellular concept of specificity of training.

The present researcher being a qualified coach as well as a physical educator had to confronted with many odds in the training and conditioning process followed in various institutes in the country. The researcher has the conviction of “training specific performance” and the present investigation gave him the opportunity to search in depth his view point in this regard. Furthermore, he presumed that “Catch Them Young” is not merely a slogan but it requires immediate attention and nourishment. Therefore, he wanted to conduct his study on the young potential athletes.

The research reports are presented in this thesis in five separate chapters. The first chapter ‘Introduction’, has covered a wide spectrum on the perspectives of training. The history, principles, methods, types of training have been discussed with emphasis on ‘effects of training on different performance affect factors’. Related literature has been reviewed, as far as practicable, in the second chapter. Elaborate discussions on materials, methods Including procedures of tests & measurements and the training schedule, have been made in chapter three. Chapter four dealt with presentation of data, statistical analysis and discussions on the findings. Summary, specific conclusion on the basis of the findings and recommendations are presented in chapter five. Finally, a vast list of references have been presented in 'Bibliography'.

The researcher will be delighted if the information given in this thesis be j useful to any person interested in sports science.

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LIST OF ABBREVIATIONS

ATP = Adenosine Triphosphate
ANOVA = Analysis of Variance
Approx. = Approximately
BLA = Blood Lactic Acid
BMI = Body Mass Index
CD = critical Difference
cm = centimeter
cycle. Minute = Cycle per Minute
df = Degree of Freedom
EDTA = Ethylenediamine Tetraacetic Acid
Fat% = percentage of fat
GH = Growth hormone
g/dL = gram per Decilitre
HCT = Hematocrit
HGB = Hemoglobin
HVO = High-Velocity Overloads
Kg = Kilogram
Kg/m2 = Kg Per Meter square
LH = Left Hand
LMB = Lean Body Mass
LSD = Least Significant Difference
MD = Mean Difference
mt. = Meter
meter. Cycle = meter per Cycle
ATP = Adenosine Triphosphate
meter · second-1 = Meter per Second
meter2. (second. cycle)-1 =Meter square per Second per Cycle
Min. = Minimum
mins = minute(s)
Mmol/L = Millimole Per Liter
Max. = Maximum
No = Number
OBLA = Onset of Blood Lactate Accumulation
PB = Personal Best
PLT = Platelets
RBC = Red Blood Cell
RH = Right Hand
SE = Standard Error
SI = Stroke Index
SL = Stroke Length
SR = Stroke Rate
SD = Standard Deviation
Sec = Second
tSR = Time taken of 3 Stroke Cycle
WBC = White Blood Cell
Wks = Week(s)
V = Velocity
VO2 max = Maximum Volume of Oxygen Consumption
x106/µL = millions per Microliter
x103/µL = Thousands per Microliter

CHAPTER-I

INTRODUCTION

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CHAPTER-I

INTRODUCTION

1.1. GENERAL INTRODUCTION

Wisdom of training procedure including adequate physiological, psychological, nutritional techniques for optimizing athletic performance has increased comprehensively over the current century, and indisputably this new learning has made contribution to the overall changes in human sports performance. Major changes of philosophy have included the much earlier initiation of training and spacious increase in the total volume of requisite preparation (Zeigler, 1977).

The modern athletic training was begun during Ancient Greece and early Roman period. With the rise of Greek civilization and its desire to acquire physical excellence through athletics produce the professional specialists of coaching and the advancement of specialists. Professional coaches and trainers also played vital role in life of ‘Gladiators’ of early Roman empire. Herodicus, a Roman was a doctor as well as coach in the ancient Olympic Games. For many centuries following the decline of Roman period, there was compete shortfall of interest in sports activities. It was not until the commencement of the European Renaissance that sports activities softly acquired a growing popularity (Arnheim & Prentice, 2000).

The modern sports training concept as we know it come into the existence during the later period of the 19^{th} century with the firm establishment of National and International games and sports.

Swimming is an individual or team sport that requires the use of one’s arms and legs to move the body through water. Competitive swimming became popular in the 19th century. The goal of high-level competitive swimming is to break personal or world records while beating competitors in any given event. Swimming in competition should create the least resistance in order to obtain maximum speed. However, some professional swimmers who do not hold a national or world ranking are considered, the best in regard to their technical skills. Typically, an athlete goes through a cycle of training in which the body is overloaded with work in the beginning and middle segments of the cycle, then the workload is decreased in the final stage as the swimmer approaches competition.

Swimming which was considered to be only a survival activity has now developed into one of the most popular competitive sports at the international and Olympic level. This perhaps one of the few sports where ever increasingly performance is evident now and then and swimmers have attended incredible standards at a relatively much younger age. Where a certain level of physical and mental maturity is necessary before one can understand such sports (Freeman, 1980).

1.2. SPORTS TRAINING

In word "**Training**" means separate things in separate fields. In sports field the word 'Training' usually understood to be a synonym of doing physical exercise. In broad sense, training today is used to mean any organized instruction whose aim is to raise man's physical, physiological psychological, mechanical or intellectual performance instantaneously. In a narrow sense, training is doing physical exercise for the advancement of performance. In addition to sports training, competition and use of other factors which are complementary to sports training and competition comprise the total system of preparation of athletes for excellent performances. In the strict sense, sports training is the physical, physiological, psychological, intellectual, technical or moral preparation of a sportsman by means of physical exercise by applying workloads.

Sport training is a systematic and scientific process spreading over a long time. For highest achievement the system of training has to be based and conducted on scientific facts and lines where it is not possible to do that, the training has to be based on the results. Successful practice which has withstood the test of time sport. The knowledge and information acquired from these sciences have to be brought into actual practice. The sports training principles serve the purpose of applying this knowledge into practice. These principles serve as directives teachers, coaches and sportsperson for formulation, implementation and control of sports training on the basis of knowledge acquired from different training science disciplines. Singh, (1991), Harre, (1982), Matveyev, (1981) have analyzed the theoretical basis of training principles and identified the followings as cardinal principles of training. These principles are (i) Progression of load, (ii) Continuity, (iii) Planned and Systematic training, (iv)

Individualization, (v) Active participation, (vi) General and Specific preparation, (vii) Clarity, (viii) Cyclicity and (ix) Ensuring results (Singh , 1991).

The goal of sports training is to enhance the sports performance in competition to make more successful in chosen sport. It is the aggregate of both physical fitness and the sports skills. They are based on well scientific principles and proven training techniques to create a customized, effective workout plan. Such a training program, combined with difficult work, will improve quickness, speed, strength, flexibility, agility and stamina.

The required level of maturity for the swimmers is to develop through proper sports training. Enhancing the performance level of the swimmers, a complete training programme is necessary in general.

1.3. TRAINING AND MOTOR FITNESS

Muscular strength and endurance are both important for swimming. Strength is the amount of force that muscles are able to produce and endurance is the ability of the muscles to perform repeated submaximal contractions over time. In swimming, muscular strength dictates how much amount force swimmer muscles are able to produce to the water, which in turn propels swimmers' body forward. Swimming alone can positively build muscular strength. The water acts as resistance that the muscles have to overcome. Therefore, with consistent swimming, the muscles accept and become stronger. Those who have been swimming compatible for a period of time, however, will discover that because of their muscle acclimatization, the water resistance no longer gives sufficient of a stimulus to challenge their muscles and improve more strength. At that point, those who are looking to develop their swimming performance can incorporate strength-training exercises into their governance to continue to build strength.

Swimming needs muscular endurance. As a survival skill or endurance activity, it demands adequate cardiovascular improvement to ensure increased oxygen-delivery to all the involving muscles throughout the swimmer's body. Thus, as a swimmer, cardiovascular ability informs its overall power-output, and endurance is the working abstract of that physiological interplay. It is a swimmer's trait that swimming both demands and improves.

Growth hormone (GH) has a more direct role in enhance in muscle strength and hypertrophy than previously believed. It is already vastly accepted that exercise, particularly high-intensity resistance exercise, stimulates growth hormone secretion. As a result, enhance in muscle strength and size are likely to be the coupled effect of the somatomedin hypothesis combined with the direct action of growth hormone on myostatin (Liu, et al., 2003). The normal activity of myostatin is to 'switch off' muscle increase and so mutations of the gene for myostatin commonly result in individuals that have greater muscle hypertrophy and, coincidently, a less fat mass.

Power of swimmer's arms and legs all contribute to how fast can swim. Power is important which generates greater amount of force working muscles can exert on the water the faster swimming. Limb's speed is the capacity to move an individual limb (arm or leg) quickly. In swimming limb speed in arms in legs will help generate more power in each pull or kick making for swimming faster. Good range of movement in the shoulder joint will help to get a better reach forward on every stroke and therefore be able to pull back with greater amount of force allowing us to swimming faster. It will also enhance the stroke rate and allow swimmer to swimming faster. Good range of movement in the hips will allow us to kick with much amount power and increment the speed of kick.

Flexibility helps to improvement the muscle's capacity to lengthen through the water. One of the causes of poor performance in swimming is often due to poor flexibility, the limitation of range of movement in the joints, in specifically the shoulder and ankle joints. It constricts the extent to which a limb can be placed in the water to give maximum effect for proficient stroke technique; hence the speed and endurance of a swimmer will suffer. Where there is stiffness in a joint the muscles have to work harder to overcome this stiffness and the body is using up valuable energy which could otherwise be used to swim faster. By increasing the range of movement in the shoulder, spine and ankle joints, vital energy is saved, technique improves and the swimmer is able to swim faster, harder and longer. It also prevents injury like torn muscles and aching shoulder joints, which is very general amongst swimmers with poor flexibility. As one gets older, flexibility becomes low, even with continuous training in the water. It is therefore vital that swimmers do flexing and stretching exercises regularly. For young swimmers, mainly those who are just starting to training, it is even more vital to exercise because a marked harm of flexibility occurs between the ages of eleven and thirteen years, to sustain their natural flexibility throughout their swimming life.

Swimming associated to an aerobic-anaerobic type of sport with intermittent phases of high load as sprints, long distance etc. Successfully in all activities a swimmer carries his mass, moves in water against the force of gravity so that each excess of body fat represents an overload which additionally burdens the energy mechanisms and makes the execution of a whole series of activities, especially the jumps and sprints, long distance more difficult.

1.4. TRAINING AND ANTHROPOMETRY

A successful sport engagement demands gradual training from an advance age. Apart from training sessions, in series to succeed in contemporary sport it is essential for an athlete to possess certain genetically conditioned abilities and features. Body composition, anthropometric dimensions, and morphological characteristics play an important role in ascertaining the success of a sportsperson. Contemporary swimmers presuppose the existence of a certain body structure, of strong enduring swimmers marked by high intelligence, controlled aggressiveness, and highly developed functional and motor abilities, with a sense for improvisation and a collective sport. The analyses up to date that have researched anthropometric dimensions point to the fact that contemporary swimming is dominated by swimmers of above-average height compared to the selection pool population, and their build tends to be athletic. The relation between height and body mass is equally important due to the fact that modern swimming sports.

Research findings of a study showed that the athletes' somatotype and anthropometric characteristics are related to the type of each sport. In addition, there is a relationship between high athletic performance and physical characteristics, like height, low percentage of body fat and high muscle mass.

An elevated lean body mass and a less relative fat mass are morphological characteristics common to top-level male and female athletes, specifically in sports where speed, power and strength are most important. Swimmers, however, exhibit to have moderately higher levels of body fat than other top-level athletic groups (Thorland, et al., 1983). A certain level of body fat may be helpful for the swimmer, by increasing buoyancy and body position in the water, or by providing rounded body surfaces which are more suitable for streamlining with low drag characteristics (Stager, Cordain, & Becker, 1984). Male swimmers are firstly of an ectomesomorphic somatotype while females are mainly endomesomorphic (Siders, Lukaski, & Bolonchuk, 1993). Stager, Cordain, & Becker, (1984) reported that the sprint swimmers in a group of female twelve to thirteen years competitive swimmers had a greater fat free mass but did not differ in body fatness from the long-distance swimmers. Nevertheless, sports scientists and coaches at the top level of swimming place an emphasis on the acquisition of low levels of body fat and consequently routine the controlling of subcutaneous body fat is undertaken.

1.5. TRAINING AND HEMATOLOGY

The blood of all the participants exposed to exercise and training does not respond exactly similar manner. As the metabolic rate increases during exercise, the activities of the blood become more vital for improvement of performance. We shall be discussing the various changes that take place within the blood in order to meet these increased demands.

The effect of exercise on the blood volume depends on the type and intensity of exercise, trained condition of sportsperson acclimatization to heat. The endurance training, rest condition blood volume increases approximately by eight percentages. Such an increase in a higher intensity of training. Such an increase in blood volume is caused by a 12-percentage increase in the plasma volume and a slight increase in the red blood cells volume (Convertino, Brock, Keil, Bernauer, & Greenleaf, 1980). During strenuous exercise in a hot climate, the sweating rate is from 1 to > 2 liter per hour. This increased sweating may reduce the total blood volume by 3 percentages or more (Harrison, 1985).

During exercise in the bicycle, the blood volume decreases (hemoconcentration occurs) in an untrained subject with increasing intensities of exercise during cycling, there will be a greater hemoconcentration. The plasma volume reduces maximally by about 15 percentages which reveals 8 percentages decrease in the total blood volume (Senay & Kok, 1977).

The significance behind such hemoconcentration effect during bicycle exercise is probably as follows: (a) Due to muscular concentration, the compression of veins occurs. This leads to a less amount of blood leaving the capillaries than that enters throughout the arteries. Finally, within the capillaries the pressure is increased that forces some plasma out of the capillaries to the tissue spaces. (b) With increasing intensities of exercise, a greater accumulation of lactic acid and the production of other metabolic end products (potassium, phosphate) occur. These take-out plasma water from the capillaries.

An increase in the plasma volume is caused by two phenomena's: (a) A greater retention of plasma protein called albumin. It is a major contributor to osmotic concentration of plasma. When the plasma protein increases, as a result more mount of fluid is retained in the blood. (b) During exercise there is an increase release of anti-diuretic hormone and aldosterone. These hormones cause the kidneys to retain water which increases the blood plasma.

Hemodilution is observed in trained subjects during long duration exercise in hot humid climates. A fraction of this blood volume is shifted to the skin, away from the active muscles, and heavy sweating reduces the plasma volume.

A trained athlete with greater volume of blood is able to meet the circulatory demands of the active muscles and the skin than the untrained subjects. During a standard exercise, the trained subject shifts less volume of their blood to the skin vessels than the untrained subject. The reason being the trained are better capable of losing heat through sweating. Any alteration in the blood volume may influence the aerobic capacity. This occurs due to an alteration in the stroke volume and maximal cardiac output that finally affects the oxygen transport capacity or VO_2 max.

During exercise, when hemoconcentration occurs, the RBCs count will increase. With hemodilution, the RBCs count will be decreased hemoconcentration there is no change in the total number of capillaries to a great extent. The hemoconcentration occurs in order to increase the RBCs per unit of blood, which shall increase the oxygen carrying capacity of the blood. This proves to be a significant contribution towards endurance performance.

Following endurance training, there may be an increase in the RBCs count. However, an increase in the plasma volume is much higher that causes a greater fluid friction of the blood (Green, Sutton, Coates, Ali, & Jones, 1991). An increase in the plasma volume reduces the viscosity of the blood; resulting in less resistance to flow of blood. Such a mechanism may aid endurance performance. The reduced blood viscosity helps in the easier movement of the blood without much resistance within the capillaries. Thus, it could be mentioned that reduced blood viscosity enhances the oxygen supply to the active tissues during endurance exercise.

Hemoconcentration may increase the red blood cell concentration by 20 to 25 percentages. An increase in the hematocrit by 40 to 50 percentages also occurs. But the total number of red blood cell content may not change. The hematocrit is the percentage of the total volume of blood that contains the total red blood cell. The hematocrit is measured by centrifuging a blood sample in a tube until the red blood cell settle down at the bottom. A hematocrit of 40 means that 40 percentages of the blood constitute in the red blood cell. (Tiwari S. , 2006)

Any decrease in the hematocrit, when the plasma volume is not measured, would reveal a decreased red blood cell production or increased red blood cell destruction. This may reduce the oxygen carrying capacity of the blood.

When the plasma volume is measured in a trained subject who is acclimatized to heat during rest or after exercise, no deficiency of red blood cell is evident. The decrease in the hematocrit may occur though an increase in the plasma volume which is a beneficial factor. When an untrained subject performs bicycle exercise his blood volume decreases.

On the contrary, when a trained subject stops training (detraining occurs), there is a reduction in the plasma volume which would decrease the vo2 max to a great extent (Coyle, Hemmert, & Coggan, 1986).

During exercise, the degree of hemoconcentration or hemodilution determines the hemoglobin concentration. The hemoglobin will increase with hemoconcentration and falls with hemodilution. Following endurance training, the production of red blood cell slightly increases. In turn, there is also a slight increase in the total hemoglobin concentration.

With an increase in plasma volume, the hemoglobin also gets diluted. Due to these reasons, some athletes inspite of having a normal hemoglobin level, may appear to be anemic. Such a case can be treated by a period of rest for few days. During such period, the level of aldosterone returns to normal and the kidneys unload the extra sodium ions and water in the form of urine.

A low level of hemoglobin denotes anemia. Endurance athletes are greater prone to anemia as they lose iron through sweat. Faces, intestinal and bladder bleeding, and the poor absorption of iron (Haymes & Lamanca, 1989). In the females, especially an additional loss of iron occurs during menstruation. Approximately one mg of iron is lost in the sweat and faces in both the sexes every day.

Therefore, severe anemia may affect the vo_2 max and the endurance performance. An intensive endurance training program may decrease the hemoglobin (Frederickson, Puhl, & Runyan, 1983). Therefore, as the endurance event relies heavily on the oxygen supply, necessary dietary manipulation should be administered to improve hemoglobin concentration in athletes. The recommended daily intake of irons is 10 milligram and 14 milligrams for males and females respectively. The adequate dilatory iron intake and the deficiencies may be corrected after analysis by iron tablet or liquid substances (Clement & Sawchuk, 2012).

While the critical role of hemoglobin in aerobic exercise has been good accepted, there is nevertheless a great deal of controversy about the appeasement hematological variables in the sportspersons. The elementary part of this review will examine the question of anemia in sportspersons. The greater portion finding in sportspersons is a dilatational anemia that is caused by a plasma volume continuation, rather than an actual loss of blood. It is not an abnormal physiological condition and normalizes with training desistance in three to five days. This existence should be prominent from states connected with submissive blood counts, such as iron deficiency anemia. The appraisement of true anemia conditions in the sportsperson must take into account not only blood losses secondary to exercise, such as foot strike hemolysis or iron losses through sweat, but non-athletic causes as good. It is depending on the age and sex of the sportsperson; discretion must be given to appraisal of the gastrointestinal or genitourinary systems for loss of blood. Finally, a comprehensive nutritional status must be taken, as sportspersons, especially female, are frequently not consuming adequate dietary iron. While there have been studies demonstrating an increased risk of sudden death in people with sickle cell trait, it is still quite rare and should not be used as a restriction to activity. Further, studies have demonstrated that patients with sickle cell trait have an exercise capacity that is near normal or probably normal. However, in the cases of sudden death, it has been secondary to rhabdomyolysis occurring among sickle cell trait athletes performing at intense exertion under hot states, soon after arriving at altitude. The recommendations are that sportspersons with sickle cell trait adhere to consent with the general principles for fluid replacement and acclimatization to hot conditions and altitude. The final section of the paper examines the issue of hematological manipulation for the purposes of ergogenic development. Although examinations with blood doping revealed developments in running time to exhaustion and maximal oxygen uptake, the introduction of recombinant erythropoietin has rendered blood doping little more than a historical footnote. However, the developments in sports performance are not without risk, and the use of exogenous erythropoietin has the potential for increased viscosity of the blood and thrombosis with potentially fatal results. Until a definitive test is developed for detection of exogenous erythropoietin, it will continue to be a part of elite sportspersons (Shaskey & Green, 2000).

1.6. TRAINING AND BLOOD LACTIC ACID

Blood lactate is through the Glycolytic System that the role and generation of blood lactate becomes apparent. Retraction the end product of glycolysis is pyruvic acid. When this is converted into lactic acid it speedily separates and discharges hydrogen ions. The residual compound then assembles with sodium or potassium ions to form a salt called lactate. Far from being a waste product, the construction of lactate allows for the continued metabolism of glucose through glycolysis. As long as the clearance of lactate is matched by its occurrence it becomes a vital source of fuel.

The term ‘accumulation’ is therefore the key, as an enhanced production of hydrogen ions will have no detrimental effect if clearance is just as quick. During less intensity exercise blood lactate levels will remain at close to resting levels as clearance matches production. As exercise intensity enhances there comes a break point where blood lactate levels will start to increase. This is often mentioned to as the lactate threshold. If the exercise intensity continues to increment a second and often more obvious increment in lactate accumulation is observe. This is mentioned to as the lactate turn point.

The blood concentration of lactate depends on the rate of diffusion from the muscle fiber into the blood stream. This is a relatively slow process. At normal temperature, peak blood concentrations are reached 1-2 min. after a brief maximal effort. However, the time lag may be prolonged in cold water. The ratio of intramuscular to blood lactate concentration is influenced by the following factors: (a) Total muscle volume that is anaerobically active. (b) Total circulating blood volumes (Shephard , Bouhlel, Vandewalle, & Monod, 1989). (c) Proportion of carbohydrate in the diet and thereby the glycogen store. (d) Rate of tissue buffering and the rate of diffusion of hydrogen ion (H+) from the muscles into the blood stream (Hughson & Green, 1982). (e) Rate of metabolism of lactate (Sidney & Shephard , 1973). (f) The blood flow carrying lactate away from the active muscles especially during recovery. (g) Rate of excretion of lactic acid by the kidney and the sweat glands (Lamont, 1987).

Training causes a decrease in the accumulation of lactic acid during a given submaximal exercise. This is an important change, since most work, including that performed during training sessions, is to a large extent submaximal. This factor is illustrated in distance running. This requires submaximal effort over extended periods of time. Not only must these runners have a highly developed maximal aerobic power, but also in order to be successful they must be able to employ a large fraction of that power with minimal accumulation of lactic acid. This allows the runners to maintain a fast pace throughout the race without experiencing early fatigue.

A decreased lactic acid accumulation during exercise following training also means that the anaerobic threshold has increased. The physiological mechanisms responsible for a decreased accumulation of lactic acid during submaximal exercise following training are not entirely known. However, there are several possibilities as follows: (a) a greater utilization of fatty acids as a metabolic fuel to fulfill the energy requirements of the exercise would result in less glycogen usage and thus less lactic acid production by the muscles. This would be a better possibility during prolonged exercise, such as long-distance running, in which there is sufficient time for a significantly greater fatty acid oxidation, rather than the short-term exercise. (b) a smaller oxygen deficit incurred at the beginning of exercise due to a more rapid increase in oxygen consummation could also lead to less lactic acid accumulation. (c) A greater use (oxidation) of any lactic acid produced as a metabolic fuel during exercise would also result in a lowered overall lactic acid accumulation. Again, this would appear to be a more important factor during prolonged exercise because of the time factor. (d) Another possible mechanism concerning lowered lactic acid levels following training could be a result of some of the biochemical changes. For example, that the training increases the number and size of muscle mitochondria, the steady state oxygen consumption which balances the breakdown of adenosine triphosphate to adenosine diphosphate plus inorganic phosphate during exercise will be attained at lower concentrations of adenosine diphosphate plus inorganic phosphate. In other words, more mitochondria, the oxygen as well as the adenosine diphosphate and inorganic phosphate required per mitochondria will be less after training as compared with before training. Since the levels of both adenosine diphosphate and inorganic phosphate control the rate of glycolysis, there lower levels after training would cause the rate of lactic acid production to be slower during exercise at the same workload.

1.7. TRAINING AND SWIMMING PERFORMANCE

To achieve the competition success at any level of competition, swimmers must include a specific training schedule to maintain or increased strength and power, improve movement pattern and limit the risk of injury (Pelot & Darmiento, 2012; Newton, et al., 2002). The application of muscular force in swimming results in a horizontal displacement of the swimmers at a velocity proportional to the magnitude, and duration of the resulting force. The prime objectives of the mechanical work performed by an athlete are to overcome hydrodynamic resistance, which increased proportionally with the square of velocity. Therefore, any increase in swimming velocity demands a proportional increment of muscular force to overcome active drag and increase propulsive force (Vorontsov, 2011). Increments in muscle strength should theoretically translate into increased ability to generate propulsive force in the water, but theoretical aspects of swimming stroke mechanics were also determined the extent to which increased force transfers into faster swimming velocity (Riewald & Rodeo, 2015; Girold, et al., 2007; Tanaka & Swensen, 1998; Hawley, et al., 1992).

A dry-land program of eleven weeks of training (twice a week) using a combined intervention of strength and aerobic training in competitive swimmers produced significant improvements in dry-land strength, in the propelling force during tethered swimming and in swimming performance (Aspenes, et al., 2009).

A program of eight weeks of combined strength and swimming training (twice a week) produced significant increases in strength, power, and swimming performance during short distances in young swimmers. It seems therefore that adding ST to routine swimming training also allowed sprint performance to improve in young swimmers (Barbosa, et al., 2015; Garrido, et al., 2010).

To our knowledge, from previous some studies showed significant and positive results when combined dry-land and swimming training versus swimming training alone. To our knowledge, some studies showed significant and positive results when combining strength and swimming training *versus* swimming training alone. These studies reported positive effects on sprint and middle-distance swimming when using dry-land training programs with intensities ranging from 80 to 90% of 1RM combined with swimming training. Therefore, the authors recommended heavy-load ST programs (3 sets of 5/6 repetitions maximum with a rest interval of 2–5 min) to improve strength and swimming performance in elite swimmers. Under these recommendations, a maximum strength training program (intensities between 90 and 100% + 1 kg 1RM) using free weights resulted in significant increases of 4.4 and 2.1% in 25 and 50 m front crawl performances, respectively (Amaro, et al., 2017; Haycraft & Robertson, 2015; Barbosa, et al., 2015; Garrido, et al., 2010). Interestingly, two strength programs of six weeks, one focusing on power (3 × 15-25 s with 60–70% of 1RM) and another on hypertrophy (3x6-8 repetitions with 80–90% of 1RM), combined with the same swimming training, showed improvements in performance (Strass , 1986).

In this respect, it is important that dry-land training for swimmers should complement, not replace, sports-specific in water training, and it must enhance, not hinder, the swimmers in water sessions by improving the quality of training. Concurrent training in employed to manipulate the force-velocity curve and the ability to apply large amounts of muscle force under sports-specific conditions. A positive transfer to swimming performance must be achieved through improvements in physical, physiological and biomechanical variables. Upper body strength in particular is imperative in swimming, as most of the propulsive forces and swimming velocity are generated by the upper body musculature (Toussaint & Beek, 1992; Deschodt-Arsac, Arsac, & Rouard, 1999; Hollander, Groot, & Schenau, 1988).

A well-planned and periodized specific training programme should allow proper long-term athlete improvement, limit of risk of injury and maximize competitive performance (Riewald & Rodeo, 2015). Both dry-land and in-water strength training may have a direct influence on a swimmer's proficiency to apply force and move through the water, therefore well-designed training plans should adequately complement a swimming training throughout a session.

1.8. STATEMENT OF THE PROBLEM

The main aim of sports training is to prepare a sports person for highest level sports performance in a man completion in specific sports. A sportsman's performance depends on different factors (physical characteristics, physiological potentialities, psychological status, tactical quality etc.).

Other hand sports training influences on such factors (physical characteristics, physiological potentialities, psychological status, tactical quality etc.), so in this study to find out the changes of selected factors through specific training programme, the problem stated as "**Effect of Specific Training Program on Selected Motor Fitness Anthropometric and Physiological Parameters of Young Swimmers".**

1.9. OBJECTIVES OF THE PROBLEM

The objectives of the study are:

1. To assess the selected motor fitness variables of the young swimmers after 24 weeks of observation.
2. To measure the selected anthropometric measurements and body composition dimension variables of the young swimmers after 24 weeks of observation.
3. To measure the selected hematological parameters of the young swimmers after 24 weeks of observation.
4. To assess the blood lactic acid accumulation of the young swimmers after 24 weeks of observation.
5. To observe the changes of selected performance related variables of the competitive young swimmers after 24 weeks of specific training programme.

6. An attempt will be made to find out the relationship among the selected variables.

1.10. DELIMITATION OF THE STUDY

The study has been delimited in the following:

Area: The study has been conducted in West Bengal, India.

District: Only one districts; South 24 Parganas has been selected as the study area.

No. of subjects: Total fifteen (15) young subjects have been selected as subjects in this study.

Sex: Only male subjects have been selected.

Age: 14-16 years in age ranged students have been considered.

Category: only young sprint swimmers have been selected as subjects in the study.

Duration of observation: Only 24 week's participations in specific training program of the subjects has been considered as observation period.

Variables: Following variables with numbers of parameters have been selected for the study:

I. Five (4) parameters for motor fitness variables.
II. Nine (9) parameters for anthropometric variables.
III. Six (6) parameters for physiological & biochemical variables.
IV. Five (5) parameters for Swimming performance related variables.

1.11. LIMITATIONS OF THE STUDY

1. The subjects taken for the study were not have the same characteristics as far as the selected variables may vary from person to person.
2. Psychological and sociological conditions of their day - to - day life interactions to their environment could not be controlled.
3. The food habits, hereditary aspects life styles of the subjects were not ascertained and this may influence the study.
4. Small number of young swimmers and 24 weeks observation employed in this study, the researcher think, may influence the study.
5. One training programme may also affect the other training programme due their growing age and training age is considered as limitation.

6. Performance is a discrete task and depending on influences on a number of factors in the present study all such factors to not be considered, which may be considered as limitation.

1.12. HYPOTHESES OF THE STUDY

1. It is hypothesised that there would be significant improvement on motor fitness variables of swimmers following specific training.
2. It is hypothesised that there would be no significant changes on anthropometric measurements and body composition dimension variables of swimmers following specific training.
3. It is hypothesised that there would be significant changes on hematological parameters of swimmers following specific training.
4. It is hypothesised that there would be significant changes on blood lactic acid accumulation of swimmers following specific training.
5. It is hypothesised that there would be significant changes on performance related variables of swimmers specific following training.
6. It is hypothesised that swimming performance would be significantly related to selected motor fitness, anthropometric physiological and performance related Parameters respectively.

1.13. SIGNIFICANCE OF THE STUDY

The present study may contribute towards the development of swimming, in the following ways-

1. The results of the study may help utilised as a screening tool for assessing and classifying of the swimmers according to their quality.
2. The results of the study may provide the coaches with the knowledge and information of the specific qualities which are to be possessed and developed by the swimmers for achieving success.
3. The study may help the coaches and physical education teachers in planning effective training schedule for the swimmers.
4. Criteria for selecting the promising swimmers may be developed on the basis of the results of the study.

5. The swimmers may be profited from the results of the study by knowing the contribution of some selected motor, anthropometric and physiological variables toward achieved successful performance in swimming.
6. The study may encourage some other scholars having interest in swimming to undertake research works of similar nature which ultimately help in the improvement of the standard of swimming in the country.

1.14. DEFINITION OF THE TERMS

Sports training

Sports training are the basic form of an athlete's training. It is the preparation systematically organised with the help of exercise, which in fact is a pedagogically organised process of controlling an athlete's development (his sporting perfection). (Matveyev, 1981)

Motor Fitness

A readiness or preparedness for performance with special regard for big muscle activity without under fatigue. It concerns the capacity to move the body efficiently with force over a reasonable length of time. (Barrow & McGee, 1979)

Muscular strength and endurance

It is the ability of the muscle to generate force during a short period time and also to get over resistance in the case of endurance loads of medium intensity of stimuli and resist muscular fatigue. (Uppal, 2004)

Leg explosive strength

It is the capacity of the individual to bring into play maximum muscle contraction at the fastest rate of speed. (Barrow & McGee, 1979)

Power may be defined as the ability to release maximum force in fastest possible times. (Johnson & Nelson, 1982)

Handgrip muscular Strength

Handgrip strength is a measure of strength of several muscles in the hand and the forearm.

Flexibility

Flexibility is the ability to move the body and its parts through a wide range of motion without undue strain to the articulations and muscle attachments (Johnson & Nelson, 1982)

Anthropometric measurements

Anthropometric measurements ore dimensions of the structure of the human body taken at specific sites to give measures of length, girth and width. (Mathews, 1978)

Height

Height as the distance extending from the lowest point to the highest point of a human being in a natural standing position. (Philips & Hamek, 1979)

Weight

Weight of the nude human body with empty bowels, is known as body weight. (Kansal, 2008)

Chest circumference

It is the maximum perimeter of the chest measured at meso-sternal point at the end tidal of normal expiration. (Kansal, 2008)

Shoulder Width

Shoulder width is the distance between two acromial processes measured with the help of spreading caliper while the subject sits erect or standing with arms hanging down freely on the sides, with the Frankfort plane. (Kansal, 2008)

Arm Span

The linear horizontal distance between the dactylion sites (tip of the middle fingers) with the arms extended laterally and at shoulder level. It includes the width of the shoulders and length of both the upper limbs. (Kansal, 2008)

Body composition

Body composition is the amount of fat mass compared to lean muscle mass, bone and organs, and it is one of the most important morphological features characterizing human organism.

Body Mass Index (BMI)

Body mass index (BMI) is a value derived from the mass (weight) and height of a person. The body mass index is defined as the body mass divided by the square of the body height, and is expressed in units of kg/m^2, resulting from mass in kilogram and height in meters.

Percentage Body fat

This describes the percentage of total weight that is composed of fat. Body fat percentage is that percentage of body mass that is not made up of bone, muscle, connective tissue and fluids; that is, everything else.

Lean body mass

The mass of tissue which does not contain fat; it is the total body mass minus the total body fat. (Kent, 1993)

Haematology:

Haematology**,** also spelled haematology**,** is the branch of internal medicine, physiology, pathology, clinical laboratory work, and paediatrics that is concerned with the study of blood, the blood-forming organs, and blood diseases. Haematology includes the study of ethology, diagnosis, treatment, prognosis, and prevention of blood diseases.

Red Blood Cell:

RBC Shorts for red blood cells that carry oxygen and carbon dioxide through the blood. This rather remarkable feat is thanks to haemoglobin, the pigment that makes red cells (and blood) look red. The red blood cells are also known as red corpuscles or erythrocytes (literally, red hollow vessels). RBC also stands for the red cell count, the number of red blood cells in a given volume of blood.

White Blood Cell:

WBC is the any of various nearly colourless cells of the immune system that circulate mainly in the blood and lymph and participate in reactions to invading microorganisms or foreign particles, comprising the B cells, T cells, macrophages, monocytes, and granulocytes.

Platelet:

A minute, irregularly shaped, disk like cytoplasmic body found in blood plasma that promotes blood clotting and has no definite nucleus, no DNA, and no haemoglobin. Also called blood platelet, thrombocyte.

Haemoglobin:

An iron-containing protein present in the blood of many animals that, in vertebrates, carries oxygen from the lungs to the tissues of the body and carries carbon dioxide from the tissues to the lungs. Haemoglobin is contained in the red blood cells of vertebrates and gives these cells their characteristic colour.

Iron containing compound in red blood cells that transports oxygen from the lungs to muscles and other tissues. (Heyward, 2010)

Haematocrit:

Haematocrit is a blood test that measures the percentage of the volume of whole blood that is made up of red blood cells. This measurement depends on the number of red blood cells and the size of red blood cells.

Blood Lactate

"The anaerobic end product of glycolysis; it has been implicated as a causative factor in the etiology of fatigue. The blood lactate (salt or ester of lactic acid) is a by-product of intense exercise, indicating the insufficient oxygen is available to fuel that exercise and leading to muscular fatigue".

The end product of anaerobic glycolysis in which the glycogen, in the absence of oxygen is broken down to lactic acid. (Tiwari S. , 2006)

Sport Performance

Sport performance is the manner in which sport participation is measured. Sport performance is a complex mixture of biomechanical function, emotional factors, and training techniques. Performance in an athletic context has a popular connotation of representing the pursuit of excellence, where an athlete measures his or her performance as a progression toward excellence or achievement. There is an understanding in sport that athletes interested in performance tend to the competitive or elite level; athletes interested in simple participation, for broader purposes such as fitness or weight control, are most often recreational athletes who do not set specific performance goals.

Velocity

Velocity is defined as the rate of change of position of an object with respect to time. As velocity is a measure of displacement this means that it is a vector quantity i.e. it must take both magnitude and direction into account whereas speed, being a scalar quantity, just accounts for magnitude.

Stroke Rate:

The number of strokes take per minute (counting both left and right arm).

Stroke Length:

The distance travelled (in meters or yards) from each individual stroke.

Stroke Index

It is a performance index. It is an indicator of how efficiently moving through the water. (Costill, et al., 1985)

CHAPTER-II

REVIEW OF RELATED LITERATURE

2.1. Acquisition of evidences

2.2. Inclusion and exclusion criteria

2.3 Selection procedure of review articles

2.4. Allied Review of Related Literature

2.5. Critical Review of Related Literature

2.6. Summary of Literature

2.7. Review conclusion

CHAPTER-II

REVIEW OF RELATED LITERATURE

The present chapter consists of different research studies related to the study under research. A search for the reference materials would support the researcher to determine the effectiveness of the different combinations of the parameters, methodology applied and the results obtained. Study of the related literature constructed loading, reading and analyzing reports of investigation as well as reports of casual observation and opinion that are related to the individuals planned investigation report. A study of relevant Literature is an indispensable step to get a complete picture of what has been done with consideration to the problem under study. The researcher has made an effort to bring a summarized review of research related to the present study to form the hinterland for the present study.

2.1. Acquisition of evidences

in this study, a comprehensive online searching method was applied for acquisition of evidences. The electronic databases: Google Scholar (Scholarly index and bibliographic database); PubMed (Biomedical); DOAJR (Peer reviewed open access); Scopus (Life science, social science, physical science and health science); IndMED (Biomedical); Shodhganga (UGC Inflibnet); Europe PMC (Biomedical); Medline (Medicine); Web of Science (Science, social science, art and humanities); Embase (Biomedical) and PsycINFO (Psychology) were sensibly searched for reviewing the related literatures.

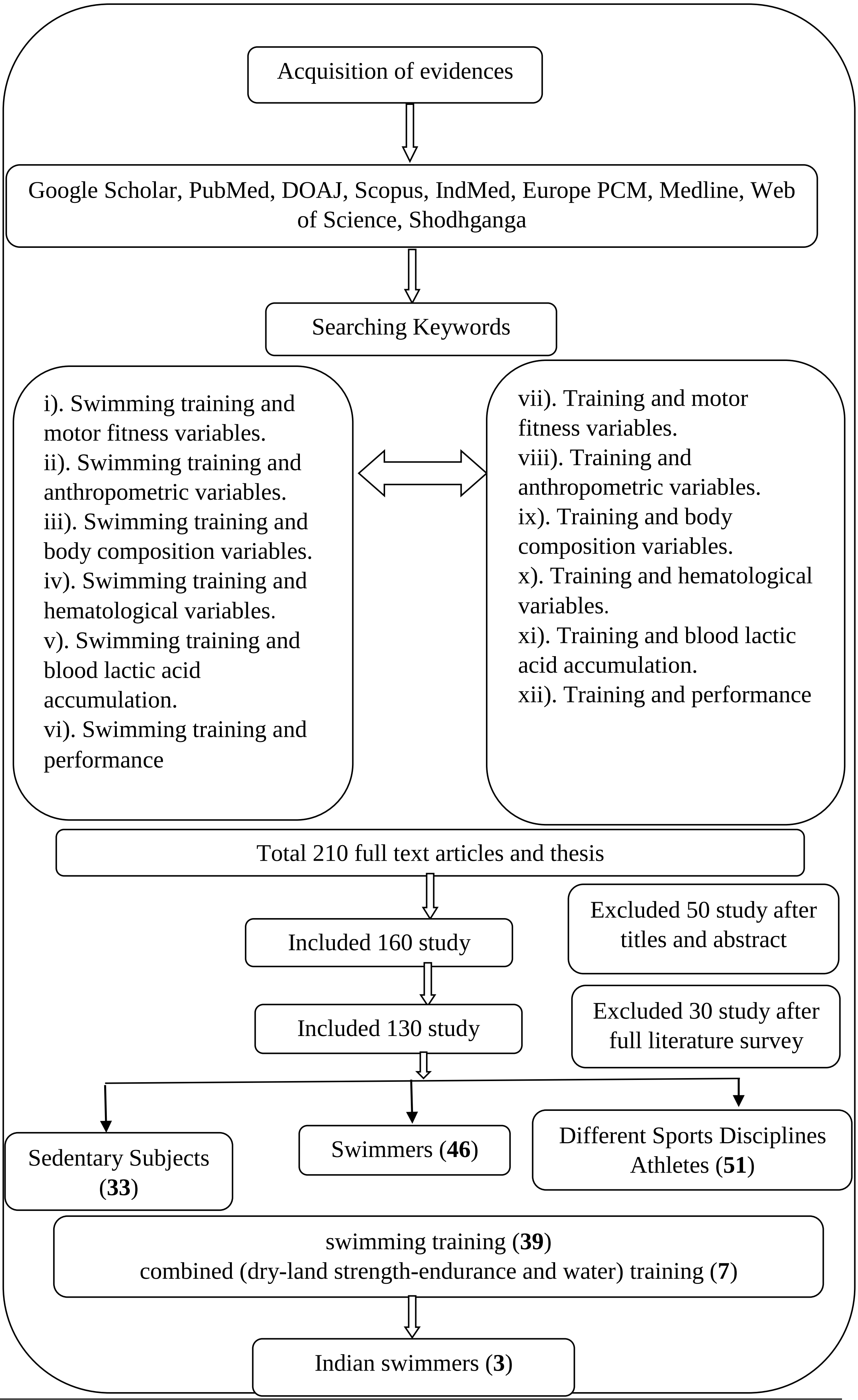
2.2. Inclusion and exclusion criteria

Studies related to the objectives of this study were included in this research, whereas studies which were not directly matched with the concept of objectives were excluded from this procedure. In inclusion criteria, keywords were focused with the areas of Swimming training and motor fitness variables; Swimming training and

Anthropometrical variables; Swimming training and body composition variables; Swimming training and physiological variables; Swimming training and blood lactic acid; Swimming training and swimming performance; Training and motor fitness variables; Training and Anthropometrical variables; Training and body composition variables; Training and physiological variables; Training and blood lactic acid; Training and swimming performance etc.

2.3 Selection procedure of review articles

In the first attempt, total 210 articles' titles were identified on the basis of eligibility criteria. After collecting the entire articles and surveying the abstracts, 50 papers were excluded primarily on the basis of title and the ambiguity of the text. After literature survey of other papers, only 130 articles satisfied the objectives of this study and the rest were excluded (n=30) from the review procedure. Finally, full text articles were assessed strictly on the basis of eligibility criteria. All the review selection procedures are presented in the following flowchart-


Acquisition of evidences
Google Scholar, PubMed, DOAJ, Scopus, IndMed, Europe PCM, Medline, Web of Science, Shodhganga
Searching Keywords
i). Swimming training and motor fitness variables.
ii). Swimming training and anthropometric variables.
iii). Swimming training and body composition variables.
iv). Swimming training and hematological variables.
v). Swimming training and blood lactic acid accumulation.
vi). Swimming training and performance
vii). Training and motor fitness variables.
viii). Training and anthropometric variables.
ix). Training and body composition variables.
x). Training and hematological variables.
xi). Training and blood lactic acid accumulation.
xii). Training and performance
Total 210 full text articles and thesis
Included 160 study
Excluded 50 study after titles and abstract
Included 130 study
Excluded 30 study after full literature survey
Sedentary Subjects (**33**)
Swimmers (**46**)
Different Sports Disciplines Athletes (**51**)
swimming training (**39**)
combined (dry-land strength-endurance and water) training (**7**)
Indian swimmers (**3**)

2.4. Allied Review of Related Literature

Charmas, M, and **Gromisz, W. (2019)** try to find out the effect of twelve-weeks swimming training on body composition in young women. From the study it was revealed that insignificant changes on body mass and body mass index ($p>0.05$) of experimental women subjects. It was also observed that statistically insignificant changes on fat weight and lean body mass ($p>0.05$) of young women. (Charmas & Gromisz, 2019)

Cicek, G. (2018) investigated a study on the effects of different exercise types on hematological parameters in sedentary women. It was observed that after the exercise program, there were meaningful decreases in the body weight and body mass index (BMI) in both sedentary women intervention groups ($p<0.01$). it was seen for the aerobic exercise group, the red blood cell count (RBC), white blood cell count (WBC), hemoglobin concentration (Hb) and hematocrit (Hct) values were lower and platelet (PLT) and mean corpuscular volume (MCV) higher but this result not statistically significant ($p>0.01$). It was found for the strength exercise group, the red blood cell count, hemoglobin, hematocrit and mean corpuscular volume statistically significant decreased ($p<0.01$) and white blood cell and platelet count were decreased but not statistically significant ($p>0.01$). (Cicek, 2018)

Junior, B. P. et al. **(2018)** analyzed a study on the effect of endurance training on the blood lactate and glucose minimum intensities of cyclists. It was observed that Post-training blood lactate level after maximal exercise was significantly higher than in pre-training condition ($p<0.05$). No statistically significant differences were observed between lactate minimum intensity (LMI) neither between heart rates at these intensities both in pre- training and post- training situation. Lactate minimum intensity (LMI) increased significantly ($p < 0.05$) after 12 weeks of endurance training. (Junior, et al., 2018)

Piero, W. D. et al. **(2018)** try to find out the effects of work-interval duration and sport specificity on blood lactate concentration, heart rate and perceptual responses during high intensity interval training of athletes. It was found that on significant differences in pre-exercise blood-lactate concentration. It was showed that significant differences in post-exercise blood-lactate concentration between protocols. It was also observed that no significant interaction between protocol and specific sport was observed for post-exercise blood-lactate concentration. (Piero , Valverde-Esteve, Redondo-Castán, Pablos-Abella, & Díaz-Pintado, 2018)

Sarkar, P.K., and **Das, S. S., (2018)** reported a study on influence of training on the motor fitness variables of young athletes with special references to duration. It was observed that the statistically significant improved selected motor fitness variables, such as leg explosive strength, muscular strength endurance and muscular strength after completion of 13 weeks specific training programme. (Sarkar & Das, 2018)

Garai, B. et al. **(2017)** studied the effect of exercise on platelets variables. It was reported that platelet counts increase with strenuous exercise and decreases with moderate exercise. The researchers reported that the average healthy size of platelets (PLT) may change in human. The mean platelet volume (MPV) increased immediately after long-term aerobic physical exercise. It was reported that various intensity of resistance physical exercise significant increase of mean platelet volume (MPV). It was reported that most of the studied do not found any significant increase in platelet distribution width (PDW) after regular Exercise Participation whereas effects of acute exercises on platelet distribution width (PDW) are decrease significantly. (Garai, Chatterjee, Mondal, & Mondal, 2017)

Lesinski, M. et al. **(2017)** conducted a study on the effects of soccer training on anthropometry, body composition, and physical fitness during a soccer season in female elite young athletes. It was seen that the two preparation periods, higher volumes in resistance and endurance training were performed ($p < 0.05$), while higher sprint and tactical training volumes were applied during the two competition periods ($p < 0.05$). Body height and lean body mass increased over the season ($p < 0.01$). In terms of physical fitness, significant performance improvements were found over the soccer season in measures of balance, muscular endurance, and sport-specific performance ($p < 0.05$). In contrast, it was observed that no statistically significant changes were observed for measures of muscle leg power, speed, and change-of-direction speed. Of note, variables of muscle strength (i.e., leg extensors) significantly decreased ($p < 0.01$) over the entire season. It was also found that significant performance improvements during the first round of the season for measures of muscle power/endurance and balance ($p < 0.05$). (Lesinski, Prieske, Helm, & Granacher, 2017)

Sridhar, R. and **Giridharaprasath, R. G., (2017)** conducted a study to investigate the impact of aerobic dance training on motor fitness parameters and dribbling ability of football players. it was seen that selected motor fitness parameters including agility and flexibility statistically significant improvement due to influence of aerobic dance training of training group but it was also found that no statistically significant differences of control group. (Sridhar & Giridharaprasath , 2017)

Silva, V. F. N. et al. **(2017)** conducted a study on the effects of short-term plyometric training on physical fitness parameters of female futsal players. It was observed that a significant decreased in the body fat percentage and significantly improved in flexibility and explosive power in experimental group between pre and post-test ($p<0.05$). Furthermore, it was found that the experimental group a significant lower post-test intervention values for body fat percentage and significant higher values for explosive power and flexibility of experimental group than control group ($p<0.05$). (Silva, et al., 2017)

Debnath, D. and **Ezhilmaran, N. (2016)** try to find out the effect of plyometric training on the selected motor fitness variables among collegiate handball players. it was seen that after six weeks of plyometric training the experimental group showed statistically significant improvement in the selected Motor fitness variables including leg explosive power and cardio vascular endurance ($p<0.05$). (Debnath & Ezhilmaran, 2016)

Godara, H. L. (2016) conducted a study on the effects of plyometric training program on selected motor fitness components in adolescents Handball players. It was observed that the motor fitness parameters including agility, balance, speed, explosive strength and flexibility no statistically significant of control group after 6-week ($p>0.05$). It was also found statically significant differences of experimental group in agility, abdominal muscular strength-endurance, speed, explosive strength and flexibility after 6-week plyometric training programme ($p<.05$). (Godara, 2016)

Kaplon, O. D. (2016) analyzed the effects of sixteen-weeks swimming training on anthropometric measurements of children. From the study it was revealed that statistically significant increased body mass and chest circumference and significant decreased body mass index ($p<0.05$) of both experimental groups. It was also revealed that insignificant changes of body height ($p>0.05$) in boys and girls both groups. (Kaplan, 2016)

Bekris, E. et al. **(2015)** conducted a longitudinal study aimed to examine the changes of hematological parameters in professional young football players. It was found that the mean value of hemoglobin concentration (Hb) in beginning of the preparation period (BP) was significantly lower ($P<0.05$) than end of the preparation period (EP). It was observed that the mean value of hematocrit (Hct) in beginning of the preparation period (BP) significantly lower ($p<0.05$) than end of the preparation period (EP). The result indicated that the mean value of red blood cell count (RBC) in beginning of the preparation period (BP) was significantly lower ($p<0.05$) than end of the preparation period (EP). (Bekris, Gioldasis, Anagnostakos, Mylonis, & Gissis, 2015)

Dey, S. K. et al. **(2015)** investigate a study to find out the systemic training on motor ability and rowing performance of Indian junior female rowers. It was found that body height and weight significantly and negatively correlated with performance time ($r = -0.98$) and positively with total power output ($r = 0.97$). It was observed that motor ability parameters including agility, muscular strength, muscular endurance, leg explosive power and flexibility were progressively increased after systematic training was applied on them. (Dey, Bandyopadhyay, Jana, & Ganguly, 2015)

Hillis, D. and **Okrainec, M. (2015)** investigate a study to strength and power changes during an in-season resistance training program for male Canadian Inter-university Sport volleyball players. Results of the study indicated that upper body strength endurance was significantly increased after training period ($p<0.05$). Results for lower body strength significantly increased over the course of the season ($p<0.05$). (Hillis & Okrainec, 2015)

Yuksel, F. M. et al. **(2015)** conducted a study to the effect of eight-week basic technical badminton training program on some fitness parameters of beginner level badminton players. It was observed that there were no significant differences between the training and control groups' age, height, and the mean body weight ($p> 0.05$) after 2 months of training. It was seen that there were significant differences in the vertical jump performance between training and control groups. Similar results in standing broad jump performance were determined between the groups. It was observed that after two months of training it was determined that the vertical jump increased for the experiment group. It was determined that the standing broad jump performance showed a significant improvement in performance for the exercise group. Interestingly, the control groups' vertical jump and standing broad jump values were found to increase significantly after 8 weeks. (Yuksel, Cengiz, Zorba, & Gokdemir, 2015)

Alam, T. et al. **(2014)** conducted a cross sectional study the effects of physical exercise on selected hematological variables of Bangladesh female athletes. It was observed that hemoglobin percentage (Hb %) was significantly lower ($p<0.001$) in B_1 and B_2 groups than control group but not significant statistically, runner (B1) had higher level of Hb than cyclist (B2). Total red blood cell count (RBC) was significantly lower ($p<0.001$) in runner group (B1) and cyclist group (B2) compared with sedentary group but not significant statistically, cyclist group (B2) had higher level of RBC count than runner group (B1). Peaked cell volume (PCV) also showed the same result, the runner group (B1) and cyclist group (B2) were significantly lower than control group but cyclist group (B2) had significantly superior ($p<0.05$) of PCV than runner group (B1). (Alam, et al., 2014)

Balaji, E. and **Murugavel, K. (2013)** studied on the motor fitness responses to core strength training on handball players. It was shows that statistically not significant ($p>0.05$) of motor fitness, such as speed, agility, leg explosive power and upper body strength in control group after 8-week. It was also observed that statistically significant differences ($p<0.05$) of motor fitness such as speed, agility, leg explosive power and upper body strength endurance in experimental group after 8-week core strength training programme. The results of the study clearly indicated that 8-weeks of core strength training programme produced significant improvements in the speed, agility, leg explosive power and upper body strength endurance of men hand ball players. (Balaji & Murugavel, 2013)

Cengiz, S. S. et al. **(2013)** studied on the effect of regular basketball education on some anthropometric parameters and vertical jump of children. It was found that no statistically significant difference between the anthropometric measurements and vertical jump values of the subjects. There was not found a significant difference between pre-test and post-test average values of hip, femur, calf and Bi-iliac. There was not found a statistical difference between the pre-test and post-test average values of vertical jump ($p>0.05$). (Cengiz, Unveren, & Karaveluoglu, 2013)

2.5. Critical Review of Related Literature

Barbosa, C. A. et al. **(2020)** investigated the effect of four-weeks training period with hand paddle on free-style swimming performance. From the study it was observed that no significant changes in swimming performance ($p>0.05$). it was revealed that no significant changes in stroke rate and stroke length ($p>0.05$) after four weeks training with hand paddles. (Barbosa, Ferreira, Gourgoulis, Leis, & Barroso, 2019)

Darchini, M. et al. **(2019)** worked on a study to identify the effect of a six-week core stability training program on the stroke index and freestyle swimming record in adolescent swimmers. From the study, results showed that the six-week core stability training program led to a statistically significant improved in the subjects 100m freestyle record ($p<0.05$), but there was statistically no significant improved in their stroke index parameter ($p>0.05$). (Darchini, Darzabi, Moghadam, & Nabavinik, 2019)

Ferreira, S. et al. **(2019)** to examined changes in physiological and biomechanical characteristics relative to 400m freestyle swimming performances during an eleven weeks training in child swimmers. From the study it was observed that swimming performance significantly increased after proposed training period ($p<0.05$). After the training period, body weight and height were also increased significantly ($p<0.05$). After the training period it was observed blood lactate concentration increased existed, but the result was not statistically significant ($p>0.05$). After the training period, the stroke length and stroke index were significantly increased ($p<0.05$) and stroke rate was significantly increased($p<0.05$). (Ferreira, et al., 2019)

Gourgoulis, V. et al. **(2019)** worked on the impact of an eleven-weeks water training program with increased resistance on the swimming performance and kinematic characteristics of front crawl stroke in young swimmers. From the study it was revealed that significant improved in swimming ($p<0.05$). it was observed that significant improved in swim velocity ($p<0.05$) after training period. It was also showed that insignificant changes were in stroke length and stroke rate ($p>0.05$). (Gourgoulis, Valkoumas, Boli, Aggeloussis, & Antoniou, 2019)

Karpinski, J. et al. **(2019)** assess the impact of a six-week specific core exercise training program on performances in national level Polish swimmers. From the study it was observed that a statistically significant improved in 50m swimming performance after the training period ($p<0.05$). After six week the study, results were improvement existed, but these results were not statistically significant of stroke rate and stroke length both parameters ($p<0.05$). After six weeks training program, it was seen that swim velocity statistically significant improved ($p<0.05$). (Karpinski, et al., 2019)

Nugent, F. et al. **(2019)** worked on a study to determine the effect of low volume, high intensity training on Performance parameters in competitive youth swimmers. From the study it was observed that no significant improved swim velocity and blood lactate concentration after specific training program ($p>0.05$). After well-planned raining program, it was observed that no statistically significant improved stroke length and stroke index ($p>0.05$) and stroke rate decreased ($p>0.05$). After seven weeks intervention period, swimming performance was not statistically significant improved ($p>0.05$). (Nugent, Comyns, Nevill, & Warrington, 2019)

Patel, S. R. et al. **(2019)** worked on a study to determine the effect on performance of young competitive swimmers. From the study it was revealed that 50m swimming kicking performance statistically increased ($p<0.05$) after twelve weeks specific training program of competitive swimmers. It was revealed that 50m swimming kicking performance and stroke rate statistically increased ($p<0.05$) after twelve weeks specific training program of competitive swimmers. (Patel, Sharma, Prajapati, Dave, & Varma, 2019)

Turgay, F. et al. **(2019)** reported that the impact of swimming training on blood nitric oxide and hematological parameters of trained child swimmers. From the study it was observed that statistically significant decreased in white blood cell, red blood cell, hemoglobin concentration, hematocrit, mean corpuscular ($p<0.05$) and no significant changes in platelets of child swimmers ($p>0.05$). it was also showed that significant decreased body mass and significant increased height ($p<0.05$) and no significant changes in body mass index ($p>0.05$). (Turgay, Ongun, Ongun, Sisman, & Colakoglu, 2019)

Grant, C. M. and **Kavaliauskas, M. (2017)** investigated that the effect of a well-structure resistance training programme in highly trained youth swimmers. It was seen that statistically significant differences explosive strength, hand grip strength, flexibility, arm and shoulder strength endurance, abdominal strength endurance, height, fat free mass, muscle mass and 100m freestyle performance. While, body mass, % of body fat, fat mass and BMI were improved but no- significant differences were observed after proposed training programme. (Grant & Kavaliauskas, 2017)

Naczk, M. et al. **(2017)** evaluated to the influence of dry-land inertial training on muscle force, muscle power and swimming performance in young swimmers. After four weeks of training, a 12.8% increase in the muscle force and 14.2% increase in the muscle power ($p<0.05$) were noted in the inertial training group. Swimming velocity in the 100m butterfly and 50m freestyle improved significantly following the four weeks of dry-land inertial training group. (Naczk, et al., 2016)

Roelofs, J. E. et al. **(2017)** analyzed the body composition, muscle characteristic and swimming performance after seasonal training of collegiate sportspersons. From the study it was revealed that statistically significant increase in body mass and fat weight ($p<0.05$) of experimental group. It was also observed that statistically insignificant changes in % of body fat and lean body mass ($p>0.05$) after seasonal training. (Roelofs , Smith-Ryan, Trexler, & Hirsch, 2017)

Morais, E. J. et al. **(2016)** try to find out impact of a specific concurrent water and dry-land training over a season in young swimmers' performance. From the study it was revealed that significantly increased in body stature, body mass and arm span ($p<0.05$) after long-term training. It was also observed that swimming performance parameters, such as swimming performance, stroke length, swim velocity, stroke index ($p<0.05$) after long-term training. It was seen that statistically significant increased ($p<0.05$) throughout training session. (Morais, Silva, Marinho, Marques, & Barbosa, 2016)

Manske, C. R. et al. **(2015)** conducted a study to effects of a dry-land strengthening program in competitive adolescent swimmers. It was seen that No differences were found between groups at the six-week measurement timeframe in any of the analyses.it was observed that experimental group gained a greater percentage of strength in each motion. However, shoulder strength endurance was statistically significant of experimental group after 12-week strengthening program. (Manske, Lewis, Wolff, & Smith, 2015)

Rodrigues-Ferreira, M. A. et al. **(2015)** assessed the effects of six-month training on body composition of pubertal swimmers. It was seen that the height significantly increased after 6-month training of all sub-groups ($p<0.001$), weight was significantly increased of swimming boys and swimming girls as well as control girls ($p<0.05$). The body mass index (BMI) insignificantly increased ($p>0.05$). After training fat weight was observed significantly decreased ($p<0.05$). (Rodrigues-Ferreira, VencesBrito, Mendes, & Fernandes, 2015)

Dingley, A. A. et al. **(2014)** evaluated the effectiveness of a dry-land resistance training programme in Paralympic swimmers to increased swimming power and strength measures, and how these changes effect in swimming performance. After the 6 weeks training period, 50m time trail improved by 1.2%. Mean power (6.1%) and acceleration (3.7%) increased during the dive start enabled swimmers to substantially improved start times to the 5m (5.5%) and 15m (1.8%) Mark's. The 6 weeks resistance training programme for Paralympic swimmers yielded substantial improved in dry- land measures that corresponded with improved in both times dive starts and 50m time trail performance. (Dingley, Pyne, Youngson, & Burkett, 2015)

Patil, D. et al. **(2014)** to assessed the added effect of core strengthening on performance in young competitive swimmers. It was demonstrated that 50m freestyle sprint time significant changes in experimental group ($p<0.05$) at the end of fourth and six weeks of training. Comparison within groups demonstrated a significant difference between baseline and four and six weeks of training. It was seen no significant differences were obtained between baseline and at the end of training for stroke rate and stroke length ($p<0.05$). A significant difference was obtained between baseline and post six weeks of training of swim velocity and stroke index ($p<0.05$). Post hoc comparison demonstrated significant improved in swim velocity and stroke index at the end of training. (Patil, Salian, & Yardi, 2014)

Schnitzler, C. et al. **(2014)** worked on a study to identify the effect of aerobic training on inter-arm coordination in highly trained swimmers. From the study it was indicated that significantly increased the swimming performance after the aerobic training ($p<0.05$). After the aerobic training programs all swimmers stroke length statistically significant improved ($p<0.05$) and it was also observed that stroke rate insignificantly decreased ($p>0.05$). (Schnitzler, Seifert, Didier, & Toussaint, 2014)

Arroyo-Toledo, J. J. et al. **(2013)** conducted a study on the effects of ten weeks block and reverse periodization training on swimming performance and body composition of moderately trained female swimmers. It was showed that significantly decreased in % of body fat and fat weight ($p<0.05$) after both training intervention period. It was also revealed that significantly increased in lean body mass ($p<0.05$) after training. It was also revealed that significantly increased swimming performance and stroke length($p<0.05$) and insignificant changes in stroke rate ($p>0.05$) after training. (Arroyo -Toledo, Clemente-Suárez, & Gonzalez Rave, 2013)

Manna, I. and **Khana, G. L. (2013)** studied on the effect of training on selected biochemical variables of elite male swimmers. It was seen a statistically significant decreased ($p<0.05$) in resting blood lactate levels and increased in peak blood lactate levels in preparatory phase and competitive phase when compared with base line data of the swimmers. It was observed that a significant decreased ($p<0.05$) in hemoglobin levels in preparatory and competitive phases when compared with base line data of the swimmers. (Manna & Khanna, 2013)

Santos-Garcia, J. D. et al. **(2013)** examined the acute effect of two resistance exercises on 25m freestyle swimming performances. It was showed that the swimming time was 0.75%, 0.41%, 1.37% and 1.37% lower post 1, 2, 3 and 4 swim trails respectively, when compared with the re-test in the resistance swimming training group. Other hand the elastic band group showed an increase of 0.95%, 0.67% and 0.95% when compared 1, 2, and 4 with the pre-test, while the post 3 time was 0.20% lower when compared with the pre-test. Finally, time was 0.87, 0.33, 0.06% and 0.26% lower when post 1, 2, 3 and 4 swimming trails were compared with the pre-test in control group. It was observed that no significant difference in 25m swimming time both group after training. (Santos-Garcia, Gonzalez-Rave, Legaz-Arrese, & Yabar, 2013)

Girold, S. et al. **(2012)** looked at twenty-four national-level competitive swimmers, who averaged 20 hours of swimming training per week. From the study it was seen that significant improved in the 50m freestyle swimming performance and Swimming velocity at the end of training in the strength training group and electrical stimulation. After 4 weeks the study, significant improvement existed, but the results were not significant from one other. After four weeks stroke length was significantly increased in the strength group not electrical stimulation group. (Girold, et al., 2012)

Li, Y. et al. **(2012)** conducted a study to describe endocrine responses and biochemical changes to low volume pre-competition swimming training in elite swimmers. It was observed that blood lactate level (BLa) significantly decreases after 2nd and 3rd week of training. Hemoglobin concentration (Hb) decrease but not significant difference was shown at 2nd and 3rd week of training. (Li, Zhu, Zhang, Zhang, & Zeng, 2012)

Sadowski, J. et al. **(2012)** randomly assigned twenty-six male swimmers to either a swimming or dry-land power training (experimental group) or swimming only (control group). The experiment group had statistically significant improved in tethered swimming force, but both groups no statistically significant differences in 25m performance. From this study it was seen that stroke rate decreased and stroke length increased, but statistically insignificant ($p>0.05$). (Sadowski, Mastalerz, Gromisz, & Niynikowski, 2012)

Soultanakis, H. N. et al. **(2012)** conducted a study to investigate the impact of 4-weeks of high-intensity vs. high-volume swimming training on lactate threshold (LT) characteristics and performance of untrained swimmers. A training effect was evident in both groups as found by the similar improvements in sprint performance of the 50-m maximum time ($p < 0.01$), peak velocity increases and the lower value of lactate at the individual ($p < 0.01$). It was seen that the Lactate threshold velocity improved only in the sprint + endurance group from 1.20 ± 0.12 m/s (-1) pre-training to 1.32 ± 0.12 m/s (-1) post-training ($p = 0.77$, $p < 0.01$). It was expressed by the rightward shifts of the individual lactate-velocity curves, indicating an improvement in the aerobic capacity. Peak lactate and lactate concentrations at lactate threshold (LT) did not statistically significantly changed. (Soultanakis, Mandaloufas, & Platanou, 2012)

Machado, V. M. et al. **(2011)** conducted a study to determine the effect of 12 weeks of training on the critical velocity and maximal lactate steady state of elite swimmers. It was observed that the results for maximum crawl sprints of 50, 100, 200, and 400 m before and after the 12 weeks of training. The 200-m and 400-m times were significantly longer before compared with after training. It was also showed that the critical velocity, the velocity at maximal lactate steady state, and anaerobic work capacity statistically significant differences before and after 12 weeks of training. (Machado, et al., 2011)

Stachowicz, M. (2011) investigate a study on the effects of swimming training on anaerobic endurance, swimming velocity and chest girth in children aged twelve years. It was seen that insignificant changes in body height and body mass index ($p>0.05$) after training. It was observed that significant increased body mass and chest girth ($p<0.05$). it was revealed that significant increased swim velocity ($p<0.05$) after training period. (Stachowicz, Milde, & Janik, 2011)

Toubekis, A. G. et al. **(2011)** examine a study of 14-week training induced changes on blood lactate profile and critical velocity in young swimmers. It was seen that the critical velocity (CV) was not different between or within groups at beginning of the training (W0) and after fourteen weeks of the training ($p > 0.05$). The lactate threshold of the experimental group was no different compared to V4 and CV at the beginning of the training (W0) and after 6-week of the training ($p>0.05$) but was higher than critical velocity at W14 ($p<0.05$). The lactate threshold (LT) increased ($p<0.05$), but velocity corresponding to blood lactate concentration of 4 mmol/L and critical velocity were unchanged after 6-week of the training ($p> 0.05$). Lactate threshold, velocity corresponding to blood lactate concentration of 4 mmol/L and critical velocity were unchanged despite the increased training volume from 6-week to 14-week (lactate threshold: 1.2 ± 4.3%, velocity corresponding to blood lactate concentration of 4 mmol/L ($p> 0.05$). (Toubekis, Tsami, Smilios, Douda, & Tokmakidis, 2011)

Vescovi, D. J. et al. **(2011)** investigate a study on blood lactate concentration and clearance in elite swimmers during competition. It was indicated that female swimmers had higher blood lactate concentration (BLa) following individual medley (IM) events compared with freestyle, breaststroke and butterfly races ($P < .034$) and that the blood lactate concentration (BLa) after freestyle events were lower compared with backstroke and butterfly events ($P < .001$). There no differences in post-race blood lactate concentration (BLa) were observed for male swimmers between the various swim strokes. The only sex difference observed was for freestyle events where men had greater post-race blood lactate concentration (BLa) compared with women ($P = .049$). It was also observed that the blood lactate concentration (BLa) increased according to increasing distances for 50 m, 100 m, 200 m, 400 m, 800 m and 1500 m events. (Vescovi, Falenchuk, & Wells, 2011)

Agaoglu S.A. et al. **(2010)** determined the effects of two months swimming training on aerobic and anaerobic capacities with blood lactate of competitive swimmers. It was seen at the 75% workload; the speed increase was statistically significant ($p<0.01$) but that of blood lactate concentration was no statistically significant ($p>0.05$). It was also observed at the 85% workload, swimmers produced 4.09 mmol/L blood lactate at a speed of 1.24 ± 0.06 m/s before the training and 4.55 ± 1.00 mmol/L blood lactate at a speed of 1.27 ± 0.07 m/s after two-month training. It was seen at the 90% workload, participants produced 5.42 ± 1.11 mmol/L blood lactate at a speed of 1.30 ±0.07 m/s before training and 6.20 ± 1.26 mmol/L blood lactate at a speed of 1.33 ± 0.08 m/s after two-month training. It was also observed at the 95% work load, swimmers produced 7.08 ± 1.11 mmol/L blood lactate at a speed of 1.35 ± 0.07 m/s before training and 7.77±1.32 mmol/L blood lactate at a speed of 1.40 ± 0.08 m/s after two months training. It was seen at the 100% workload, subjects produced 8.22 ± 0.85 mmol/L blood lactate at a speed of 1.42 ± 0.07 m/s before training and8.77 ± 0.93mmol/L blood lactate at a speed of 1.46 ± 0.08 m/s after two months training. It was observed that the increases in speed and blood lactate in all these workloads were statistically significant ($p<0.01$ and $p<0.05$). (Agaoglu, Tasmektepligil, Atan, Tutkun, & Hazar, 2010)

Garrido, N. et al. **(2010)** to examined the effects of weight weeks of combined dry-land strength and aerobic swimming training for increasing upper and lower body strength, power and swimming performance in young competitive swimmers. Regarding the 25m test, the experimental group significantly increased the swimming performance ($p<0.05$). Regarding the 50m test, the experimental group significantly increased the performance ($p<0.05$). The strength performance significantly increased ($p<0.01$) between T1 to T2 in the experimental group. (Garrido, et al., 2010).

2.6. Summary of Literature

By searching review of related literature, the researcher found total one hundred and thirty (**130**) studies. Out of one hundred and thirty (**130)** studies, eighteen (**18**) studies were conducted only on motor fitness parameters, two (**2**) studies were conducted only on anthropometric parameters, seven (**7**) studies were conducted only body composition parameters, twenty-nine (**29**) studies were conducted only hematological parameters, nineteen (**19**) studies were conducted only blood lactic acid and twenty-nine (**29**) studies were conducted only on swimming performance parameters. Whereas, four (**4**) studies were conducted on both motor fitness and anthropometric parameters, four (**4**) studies were conducted on both body composition and hematological parameters, four (**4**) studies were conducted on both body composition and motor fitness parameters, three (**3**) studies were conducted on both motor fitness and hematological parameters, two (**3**) studies were conducted both on anthropometric and hematological parameters, (**3**) studies were conducted both on anthropometric and body composition parameters, one (**1**) study was conducted on both motor fitness and performance, one (**1**) study was conducted on both anthropometric and performance, one (**1**) study was conducted on both body composition and performance, one (**1**) study was conducted on both blood lactic acid and performance, one (**1**) study was conducted on both motor fitness, body composition and anthropometric parameters. But the fact is that, all these studies were not only conducted on motor fitness, anthropometric, body composition, hematological, blood lactic acid and swimming performance related parameters.

Out of one hundred and thirty (**130)** studies, swimming training was applied in thirty-nine (**39**) studies, other sports disciplines training was applied in twenty-two (**22**) studies, aerobic training was applied in fifteen (**15**) studies, physical training was applied in eight (**8**) studies, dry-land training was applied in eight (**8**) studies, HIIT (high intensity interval training) was applied in eight (**8**) studies, resistance training was applied in seven (**7**) studies, core strengthening training was applied in five (**5**) studies, endurance training was applied in five (**5**) studies, weight training was applied in five (**5**) studies, plyometric training was applied in four (**4**) studies, combined (dry-land and water) training was applied in three (**3**), strength endurance training was applied in one (**1**) study.

Out of one hundred and thirty **(130)** studies, thirty-three (**33**) studies conducted on different ages sedentary subjects, whereas, fifty-one (**51)** studies conducted on different sports disciplines athletes and forty-six (**46**) studies conducted on swimmers. On the other hand, out of forty-six (**46)** studies, only two (**2**) studies conducted on swimming performance related parameters of Indian swimmers and one (**1**) study was conducted on hematological parameters of Indian swimmers.

2.7. Review conclusion

In the review's studies, the researcher found various field test such as motor fitness, anthropometric, body composition, blood lactic acid and performance related parameters. Whereas, lab test such as hematological parameter test was taken up for measuring performance

From the foregoing reviewing and studying the related literature carefully, the researcher found that there was some research gape and very small amount study has yet been done on Indian young swimmers. Hence, being interested the researcher undertook the present study and had thus been entitled as: "**Effect of Specific Training Program on Selected Motor Fitness Anthropometric and Physiological Parameters of Young Swimmers".**

CHAPTER-III

METHODOLOGY

3.3

3.1. Selection of Subjects

3.2. Selection of the Variables

3.3. Selection of Exercise

3.4. Experimental Design

3.5. Training Programs

3.6. Criterion Measures

3.7. Instrument Reliability

3.8. Subjects Reliability

3.9. Reliability of Data

3.10. Tester Competency

3.11. Administration of Tests

3.12. Statistical Procedure Adopted for Analysis of the Data

CHAPTER – III

METHODOLOGY

In this chapter the procedure followed and methodologies used for the present investigation have been described. It includes selection of subjects, selection of criterion measures, selection of instruments and tools, collection of data, administration of the tests, administration of the training program, reliability of the data, experimental design and statistical techniques for analyzing the data have been described.

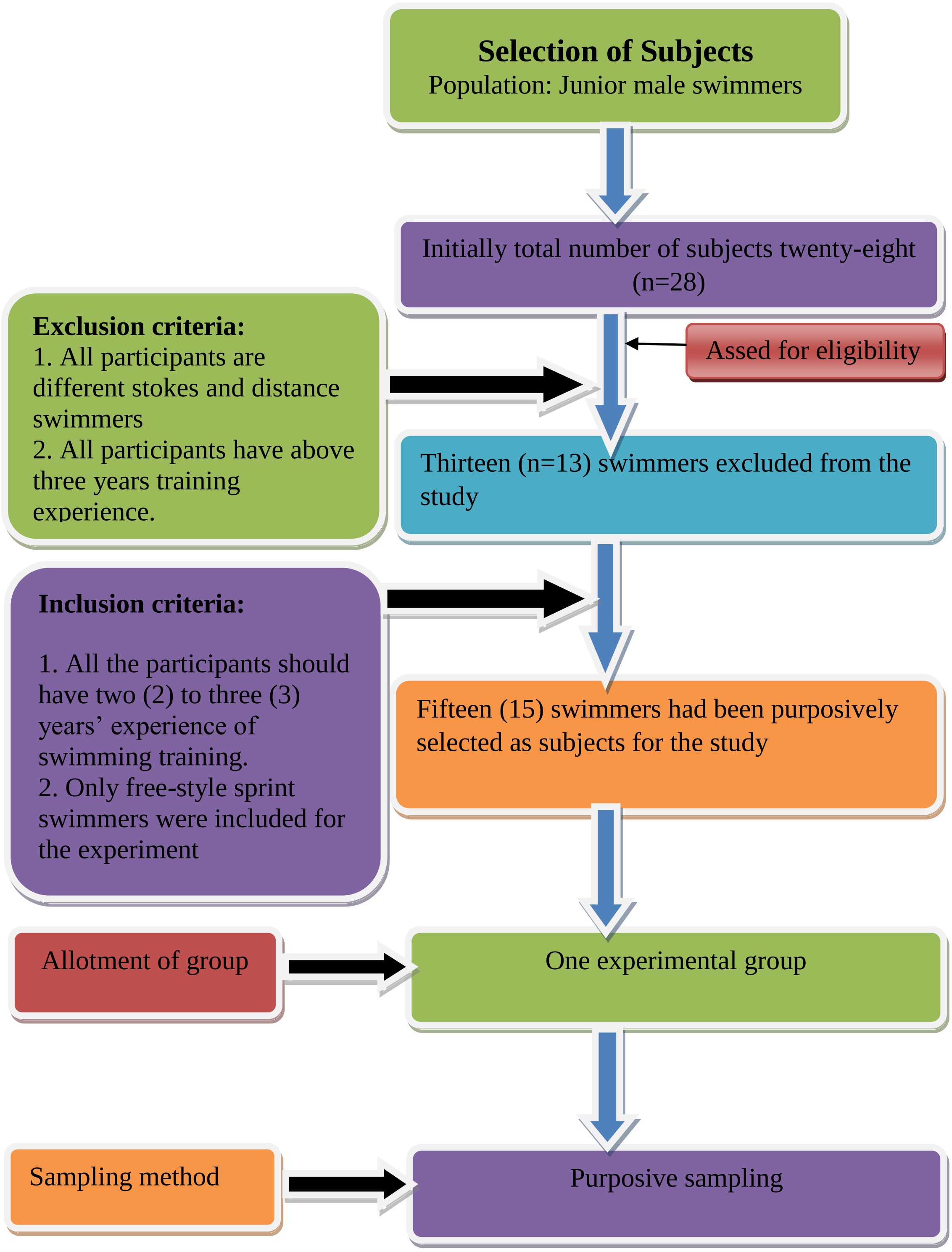
3.1. SELECTION OF SUBJECTS

Initially, twenty-eight (28) junior male district level swimmers were taken from Nimpith Vivekananda Sports Association of south 24 parganas district, ranging the age from 14 years to 16 years and their training age 2 years to 3 years. After that, thirteen (13) swimmers excluded from the study for not meeting inclusion criteria (eg. different training age, strokes and distances swimmers). Finally, fifteen (15) swimmers those are meeting inclusion criteria (only free-style sprint swimmers were considered for the study because prepare a homogeneous training programme) had been purposively selected as subjects for the study.

Fifteen (n=15) districts level male swimmers were participated in the present study (mean ± SD were: age 15.21 ± 0.77 years, height 166.06± 3.86 cm, weight 53.62 ± 2.44 kg, tanner age 2.53± 0.51 years and swimming performance 67.20 ± 3.18 sec).

All subjects were informed about their nature of physical activity. Their consent was obtained. They were motivated to co-operate till the end of the experimental period. The study was approved by Local Bioethics Committee (**Hurip Independent Bioethical Committee, 2018**). The subjects were free to withdraw their consent in case they felt any discomfort during experiment period of their participation, but there was not a single dropout during the study.

Flow chart of selection of subjects



3.2. SELECTION OF THE VARIABLES

The research scholar reviewed the various scientific literatures pertaining to various swimming training programme on competitive swimmers. After reviewed the literatures and discussed with professional swimming coaches and supervisor, researcher selected following variables. Muscular strength and endurance are both important for swimming. Swimming needs great mechanical power output and muscular strength for good swimming performance. Flexibility helps to improvement the muscle's capacity to lengthen through the water. Better performance has always been related to better swimming technique and higher anthropometrics. A certain level of body composition properties may be helpful for the swimming performance. While the critical role of hematology in aerobic exercise has been good accepted, there is nevertheless a great deal of controversy about the appeasement hematological variables in the sportspersons. Blood lactic acid concentrations at various training intensities are lower and swimmer’s speed or power at OBLA is faster or greater.

Taking into considerations of the criteria, feasibility, availability of instruments and relevance to the present experimental study, the following variables were selected.

3.2.1. MOTOR FITNESS VARIABLES: Performance development in swimming has been identified by the professional swimming coaches and exercise scientists, that muscular strength endurance in selected muscles group are very much related. Accordingly, strength endurance of relevant muscles group are measured for the purpose, through following parameters

3.2.1.1. Muscular strength

3.2.1.1.a. Hand grip muscular strength (RH and LH)

3.2.1.2. Muscular strength-endurance

3.2.1.2.a. Arm and shoulder strength-endurance

3.2.1.2.b. Abdominal strength-endurance

3.2.1.3. Flexibility

3.2.1.4. Leg explosive strength

3.2.2 ANTHROPOMETRIC VARIABLES: Following parameters were identified as very much related with the swimming performance and accordingly following parameters were considered. Anthropometric variables considered in this study was consists of -i. anthropometric measurements, ii. Body composition dimension.

3.2.2.1. Anthropometric Measurements

3.2.2.1.a. Height
3.2.2.1.b Weight
3.2.2.1.c. Shoulder width
3.2.2.1.d. Chest circumference
3.2.2.1.e. Arm span

3.2.2.2. Body Composition Dimension

3.2.2.2.a. Body mass index
3.2.2.2.b. Percentage of body fat
3.2.2.2.c. Total body fat weight
3.2.2.2.d. Lean body mass

3.2.3. PHYSIOLOGICAL & BIOCHEMICAL VARIABLES: Following parameters are relevant for Hematological and Biochemical assessment of the swimmers.

3.2.3.1. Hematological variables
3.2.3.1.a. Red blood cell count
3.2.3.1.b. White blood cell count
3.2.3.1.c. Platelets count
3.2.3.1.d. Hemoglobin concentration
3.2.3.1.e. Hematocrit
3.2.3.2. Blood lactic acid

3.2.4. PERFORMANCE RELATED VARIABLES: Following parameters were identified as very much related with the swimming performance and accordingly following parameters were considered.

3.2.4.1. 100m Swimming performance
3.2.4.2. Swim velocity
3.2.4.3. Stroke rate

3.2.4.4. Stroke length

3.2.4.5. Stroke index

3.3. SELECTION OF EXERCISE

The research scholar reviewed the various scientific literatures pertaining to various dryland training programme on competitive swimmers. After reviewed the literatures and discussed with professional swimming coaches, exercise scientists and supervisor, researcher selected following dryland exercises. Following exercises directly involved in competitive swimming related muscles groups. Some recommended exercises to enhance strength, such as two arm curls, heel raise, leg press and elastic band exercises. Explosiveness develops well on land, where swimmer has a harder surface to push off of counter movement jumps, pull-ups and push-ups are just a few exercises that develop power. Selected dryland exercises for swimming are to improve the swimmer's strength, power, athleticism, and overall speed in the pool.

3.4. EXPERIMENTAL DESIGN

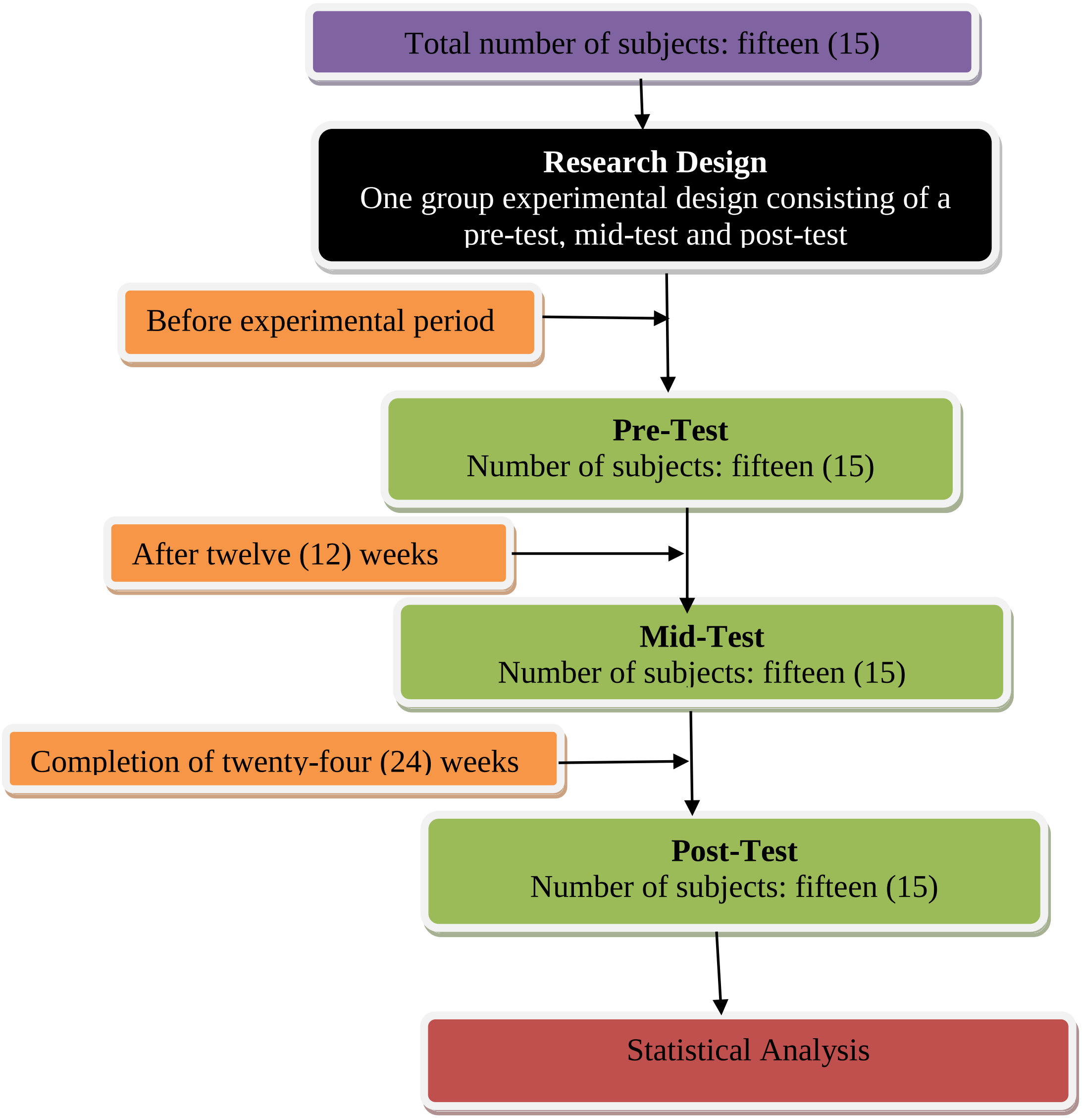
The study was assigned as a one group experimental design consisting of a pre-test, mid-test and post-test. The subjects (N=15) were formulated to a group for experiment.

Pre-test were conducted for all the subjects (N=15) on selected motor fitness, anthropometrical, body composition, physiological and performance related parameters. After the experimental period of twelve (12) weeks intermediate test and completion of the experimental period of 24 weeks post-test were conducted and score were recorded.

The experimental group was participated in their specific training program under the supervision of qualified swimming coach by given respective training to the subjects two (2) sessions of dry-land strength training program (Sunday & Wednesday evening) and five sessions of swimming training program (off day Monday & Thursday).

Before onset of training all the tests (standarised) and measurement of all the five dimensions (anthropometrical, body composition, motor fitness, physiological & biochemical and swimming performance related potentialities) were conducted on all the subjects. Post-tests on each of the variables were conducted twice, first after 12 weeks and then after completion of 24 weeks training programme, respectively. The anthropometrical, body composition and motor fitness parameters test were conducted in one days in each state of training phase (pre, after 12weeks & after 24 weeks). The test of physiological & biochemical and swimming performance related parameters test was conducted in three consecutive days taking 5 subjects in each day. It means in state of training phase five (5) days were spent for conducting the tests. The tests procedure has been discussed separately.

Flow chart of experimental design



3.5. TRAINING PROGRAMMES

The training programme has been segregated into two parts- dry-land strength-endurance training programme and swimming training programme according to the objectives of the study. All swimmers trained 2 sessions of dry-land strength-endurance training programme (Sunday & Wednesday evening) and 5 sessions of swimming training programme (off Monday and Thursday) per week. Dry-land strength endurance training was divided into three training phases, (i) maximum strength training (1-12 wks.), (ii) explosive strength training (13-18 wks.) and (iii) strength-endurance training (19-24 wks.). Swimming training programme was divided into five training zones, (i) aerobic training zone (1-12 wks.), (ii) anaerobic threshold training zone (13-16 wks.), (iii) high-performance-endurance training zone (17-20 wks.), (iv) anaerobic training zone (21-22 wks.) and (v) sprint training zone (23-24 wks.).

The training schedule and the loading procedures adopted for the present study were planned after through an elaborate discussion with the professionally experienced and specialized coaches and supervisor. The training schedule was prepared according to the method mentioned for dry-land strength-endurance training (Garrido, et al., 2010; Das, 1995; Sing, 1984), and for swimming training (Sweetenham & Atkinson, 2003; Carew & Pyne, 1999; Atkinson & Sweetenham, 1999; Pyne, 1999a; Pyne, D., 1999b; Richards, 1999). The whole training program was conducted under the supervision of research scholar and four qualified coaches and all swimmers were trained under identical facilities and environmental conditions.

3.5.a. Dry-land strength-endurance programme

The detail of the training programme has been mentioned in the **Chart-1.** To achieve the target improvement, specific strength-endurance training programme was adopted. The training programme was designed in accordance with the youth resistance training guidelines ensuring appropriate progression for each individual swimmer. Progression and technique were closely monitored by weight training Specialist and research scholar throughout the training programme with all loads monitored and recorded for each individual swimmer. The specific exercise has been presented in the chart.

The salient feature of the training programme was that in the first twelve weeks (1-12 wks.) schedule both the resistance and repetition were increased. It means for maximum strength development in the present schedule, load was gradually increased from 80% to 90% (Sing, 1984) and repetition was from 6 to 8 in number. For each exercise were practiced in 3 sets. In this phase sub-maximal load was given, due to the age and inexperience of the participants.

For development of explosive strength during thirteen to eighteen weeks (13-18 wks.) the resistance increased and repetition was decreased. Load was 70% to 75% and repetition was 12 to 10 in number. For each exercise were practiced in 3 sets.

For strength-endurance development during nineteen to twenty-four weeks (19-24 wks.) the resistance at the rate of 5% increased at the initial 50% but the repetition was remained constant at 16 in number. for each exercise were practiced in 3 sets, but some exercise such as sit-ups, pull-ups, push-ups, counter movement jump and elastic band exercises sets was 5. A recovery period of 2 to 4 minute was allowed after every set of exercise.

Chart No-1 Dry-land Strength-Endurance Training

Sl. No.	Name of the Exercise	Muscles Involves in Exercise	Resistance In % of Maximum Possible (100%)	Maximum Strength			Explosive Strength		Strength-Endurance	
				1-6 Wks.	7-9 Wks.	10-12 Wks.	13-15 Wks.	16-18 Wks.	19-21 Wks.	22-24 Wks.
1.	Two Arm Curl	Forearm Flexors, Brachioraialis	25 kg	80%x6 3	85%x7 3	90%x8 3	70%x12 3	75%x10 3	50%x16 3	55%x16 3
2.	Half Squat	Quadriceps, Gluteal, Hamstrings,	80 kg	80%x6 3	85%x7 3	90%x8 3	70%x12 3	75%x10 3	50%x16 3	55%x16 3
3.	Sit-Ups	Rectus Abdominis, External and Internal Obliques,	50 times	80% 3	85% 3	90% 3	70% 3	75% 3	50% 5	55% 5
4.	Heel Raise	Gastrocnemius, Soleus	50 kg	80%x6 3	85%x7 3	90%x8 3	70%x12 3	75%x10 3	50%x16 3	55%x16 3
5.	Push-Ups	Deltoid, Pectroralis Major, Triceps, Biceps Brachii	20 times	80% 3	85% 3	90% 3	50% 3	60% 3	50% 5	55% 5

Chart No-1 Training Schedule and Load Parameter for Experimental Period (continued)

Sl. No.	Name of the Exercise	Muscles Involves in Exercise	Resistance In % of Maximum Possible (100%)	Maximum Strength			Explosive Strength		Strength-Endurance	
				1-6 Wks.	7-9 Wks.	10-12 Wks.	13-15 Wks.	16-18 Wks.	19-21 Wks.	22-24 Wks.
6.	Pull-Ups	Latissimus Dorsi, Biceps Brachii, Deltoid,	12 times	80% / 3	85% / 3	90% / 3	70% / 3	75% / 3	50% / 5	55% / 5
7.	Leg Press	Hip joint muscles, quadriceps, lower leg, Hamstrings,	60 times	80%x6 / 3	85%x7 / 3	90%x8 / 3	70%x12 / 3	75%x10 / 3	50%x16 / 3	55%x16 / 3
8.	Elastic Band Exercises	Deltoids, Latissimus Dorsi	20 times	80% / 3	85% / 3	90% / 3	70% / 3	75% / 3	50% / 5	55% / 5
9.	Counter movement jump	Gluteus Maximus, soleus, Hamstrings, Quadriceps femoris, gastrocnemius	20 times	80% / 3	85% / 3	90% / 3	70% / 3	75% / 3	50% / 5	55% / 5
10.	Good Morning Exercise	Gluteus Maximus, Soleus, Hamstrings,	40 kg	80%x6 / 3	85%x7 / 3	90%x8 / 3	70%x12 / 3	75%x10 / 3	50%x16 / 3	55%x16 / 3

3.5.b. The swimming training schedule of all swimmers

The aerobic training zone represented swimming intensity below the anaerobic threshold. There are three types of aerobic training A1, A2, A3- provide balance to overall training and the range of aerobic development. The repeat distances to use when training at the level is 200m to 1500m, with very short rest between swims. The rest interval was 10 seconds to 20 seconds. The swimming intensity was set as 60 percent to 70 percentages.

The anaerobic threshold training zone the lactic acid accumulation begins to rise sharply. The repeat distances to use when training at the level is 200m to 400m. Shorter repeat distances use shorter rest interval. The rest interval varies according to distances, were 10 seconds for 50m, 10 to 20 seconds for 100m or 200m and 10 to 20 seconds for 200m or 400m. The rest interval was 10 seconds to 20 seconds. The swimming intensity was set as 70 percent to 80 percent.

In high-performance endurance training zone, swimmers work at high intensity that the swimmers maintain for the duration of the rest. In this training zone, swimmer produces high levels of lactic acid from high-performance endurance. The training repeats a distance that was made up of 150m, 100m, and 50m repeats. The rest interval was 10 seconds to 20 seconds. The swimming intensity was set as 80 percent to 90 percent in this zone.

Anaerobic zone training commonly referred to as lactic training. The anaerobic training zone consists of three types of lactate training; lactate production, lactate tolerance, and peak lactate training. The length of the set in this zone is shorter than it is in the first three training zones due to the increased intensity of this type of work. During this type of training repeat distances varies, such as 50m to 100m swims for lactate production, 50m to 200m swims for lactate tolerance and 100m to 400m swims for peak lactate. The rest interval was 20 seconds to 30 seconds. The swimming intensity was set as 90 percent to 95 percent.

Sprint training zone is the short maximum-speed training that is commonly referred to as high-velocity overloads (HVO). The Training repeats of 10m to 25m are best for training in this zone. The swimmers were performed 25m repeats with sufficient rest. Target time was set for each swimmer based on the method of calculating the speed training pace. After each set, the swimmer could do a 100m, 200m, 300m, or 400m swim-down. The distance should be long enough that the swimmer can swim the required speed on the next set. The intensity was set up 100 percent in this zone.

Chart 2a. Nature of work for one day/week

Phases of training: General Preparation Training zone: Aerobic (aerobic-1) Weeks: 1-4 weeks Duration: 3000m (64 minutes approx.)/ day Target time (intensity): 60% of PB Rest interval: 10sec to 20sec	
Warm-up	400m F/S, Back/St mix warm-up swim Total time-10min
Technical	1. 3x100m F/S catch up drill (Each repetition will be start on 2min) 2. 3x100m F/S rolling drill (Each repetition will be start on 2min 20sec) Total time- 13min
Aerobic endurance	3x400m F/S aerobic endurance swim (PB 60%+ 20sec rest). (Each repetition will be start on 6 min 50 sec) Total time - 20min 30sec
Strength endurance	1. 3x100m F/S kick with fins. (Each repetition will be start on 2 min 30sec) 2. 3x100m F/S pull with hand paddle ((Each repetition will be start on 2 min 30 sec) Total time-15min
Speed	-
Recovery	200m easy swim Total time-5min

Chart 2b. Nature of work for one day/week

Phases of training: General Preparation Training zone: Aerobic (aerobic-2) Weeks: 5-8 weeks Duration: 4000m (100 minutes/ day) Target time (intensity): 65% of PB Rest interval: 10sec to 20sec	
Warm-up	400m warm-up IM mix swim Total time -10m
Technical	1. 4x100m F/S sculling drill (Each repetition will be start on 2min) 2. 4x100m MS choice drill (Each repetition will be start on 2min 30sec) Total- 18min
Aerobic endurance	1. 6x200m F/S (PB 65% + 15 sec rest) (Each repetition will be start on 3 min 45 sec) 2. 2x400m F/S (PB 65% + 20 sec rest) (Each repetition will be start on 6 min 40 sec) Total time- 36min
Strength endurance	1. 4x100m F/S under water swim with fins (Each repetition will be start on 2min 30sec) 2. 4x100m back/St. pull with hand paddle (Each repetition will be start on 2min 30 sec) Total time- 20min
Speed	-
Recovery	200m easy swim Total-5min

Chart 2c. Nature of work for one day/week

Phases of training: General Preparation **Training zone: Aerobic (aerobic-3)** **Weeks: 9-12 weeks Duration: 5000m (100 mins approx.)/ day** **Target time (intensity): 70% of PB Rest interval: 10sec to 20sec**	
Warm-up	400m choice warm-up swim Total time -10min
Technical	**1.** 4x100m F/S pocket entry drill (Each repetition will be start on 2min) **2.** 4x100m back/St one hand catch up drill (Each repetition will be start on 2 min 30sec) Total-18min
Aerobic endurance	1. 5x100m MS (PB 70% + 10 sec rest) (Each repetition will be start on 1min 40 sec) 2. 6x200m MS (PB 70% + 20 sec rest) (Each repetition will be start on 3 min 20sec) 3. 2x400m F/S- (PB 70% + 20 sec rest) (Each repetition will be start on 6min 25 sec) Total-40min
Strength endurance	3X300m Hypox F/S with hand paddle (2,3,4,4,3,2 stroke one breath-change each 50m) (Each repetition will be start on 6min 20sec) Total- 19min
Speed	8x25 sprints (Each repetition will be start on 1min) Total time-8min
Recovery	1. 200m easy swim Total-5min

Chart 2d. Nature of work for one day/week

Phases of training: Specific Preparation Training zone: Anaerobic Threshold Weeks: 13-16 weeks Duration: 6000m (130 mins Approx.)/ day Target time (intensity): 75% of PB Rest interval: 10sec to 20sec	
Warm-up	400m F/S, Back/St mix (change each 50m) Total time-10m
Technical	1. 4x100m F/S catch-up drill (Each repetition will be start on 2min 30 sec) 2. 4x100m choice drill (Each repetition will be start on 2min 30 sec) 3. 4x100m B/F kick with Br/St pull drill (Each repetition will be start on 2min 30 sec) Total- 30min
Aerobic endurance	1. 4x100m MS (PB 75% + 20sec rest) (Each repetition will be start on 1min 30 sec) 2. 4x200m F/S (PB 75% + 20 sec rest) (Each repetition will be start on 2min 55 sec) 3. 4x400m F/S (PB 75% +20 sec rest) (Each repetition will be start on 5min 50 sec) Total-40min
Strength endurance	1. 4x100m F/S kick with fins. (Each repetition will be start on 2min 30sec) 2. 4x100m F/S pull with hand paddle (Each repetition will be start on 2min 30 sec) Total time-20min
Anaerobic power	2x100 MS maximum speed (Each repetition will be start on 5min) Total time- 10m
Speed	8x25m sprint (Each repetition will be start on 1min) Total - 8min
Recovery	400m easy swim Total time-10min

Chart 2e. Nature of work for one day/week

Phases of training: Specific Preparation **Training zone: High-performance endurance** **Weeks: 1-4 weeks Duration: 5000m (100 mins approx.)/ day** **Target time (intensity): 80-85% of PB Rest interval: 10sec to 20sec**	
Warm-up	600m F/S, Back/St mix (change each 50m) Total time- 10m
Technical	1. 6x100m F/S pocket entry drill (Each repetition will be start on 2min) 2. 3x100m back/St one hand catch up drill (Each repetition will be start on 2min 30sec) 3. 3x100m F/s kick with B/F pull (Each repetition will be start on 2min 40sec) Total time-25min
Aerobic endurance	1. 7x50m F/S (PB 85% + 20 sec rest) (Each repetition will be start on 55sec) 2. 8x100m F/S (PB 85% + 20 sec rest) (Each repetition will be start on 1min 25sec) 3. 4x200mF/s (PB 80% + 25 sec rest) (Each repetition will be start on 2min 55sec) Total-30min
Strength endurance	1. 5x50m Back/St pull with hand paddle (Each repetition will be start on 2min 30sec) 2. 5x50m F/S pull with hand paddle (Each repetition will be start on 2min 30sec) Total time-15min
	2x100m MS maximum speed (Each repetition will be start on 5min) Total time-10min
Speed	**1.** 2x50m as 20m fast, 30m easy (Each repetition will be start on 2min) **2.** 2x50m 15m fast, 35m easy (Each repetition will be start on 2min) **3.** 1x50m as 25m fast, 25m easy on 2min Total-10min
Recovery	200m easy swim 200m double hand back swim Total-10min

Chart 2f. Nature of work for one day/week

<table>
<tr><td colspan="2">Phases of Pre-Competition Preparation
Training zone: Anaerobic
Weeks: 21-22 weeks Duration: 4000m (90 mins approx.)/day
Target time (intensity): 90-95% of PB Rest interval: 20sec to 30sec</td></tr>
<tr><td>Warm-up</td><td>400m RIM F/S-kick + swim (change each 25m)
Total time- 10min</td></tr>
<tr><td>Technical</td><td>4x100m F/S 50m drill+25m kick+25m swim
(Each repetition will be start on 2min 30sec)
Total time- 10m</td></tr>
<tr><td>Aerobic endurance</td><td>3x200 F/S
(Each repetition will be start on 3min 20sec)
Total time- 10m</td></tr>
<tr><td>Anaerobic Power

Speed</td><td>1. 6x50m MS (PB 90% +25 sec rest)
(Each repetition will be start on 1min)
2. 1x25m MS maximum speed on 1min
3. 4x50m MS (PB 90% +25 sec rest)
(Each repetition will be start on 1min)
4. 2x25m MS maximum speed on 1min
5. 3x50m MS (PB 95% + 30 sec rest)
(Each repetition will be start on 1 min)
6. 3x25m MS maximum speed on 1min
7. 2x50m MS (PB 95% + 30 sec rest)
(Each repetition will be start on 1 min)
8. 4x25m MS maximum speed on 1min
9. 3x100m MS (PB 90% + 30 sec rest)
(Each repetition will be start on 1min 40 sec)
10. 5x25m MS maximum speed on 1min
11. 4x100m MS (PB 95% + 30 sec rest)
(Each repetition will be start on 1min 37 sec
12. 5x25m MS maximum speed on 1min
Total time anaerobic power -25min
Total time Sprint -30min</td></tr>
<tr><td>Recovery</td><td>400m easy swim-10min</td></tr>
</table>

Chart 2g. Nature of work for one day/week

Phases of training: Pre-Competition Preparation **Training zone: Sprint** **Weeks: 22-24 weeks Duration: 2500m (80 mins approx.)/ day** **Target time (intensity): 95-100% of PB Rest interval: 30sec to full rest**	
Warm-up	600m F/S, Back/St Total time-10m
Anaerobic Power	1. 4x100m MS maximum speed (Each repetition will be start on 5min) 2. 4x50m MS maximum speed (Each repetition will be start on 2min 30 sec) Total time -30min
Speed	1. 6x25m MS on 45sec- (explode the first and last 15m on alternate 25m repeats (Each repetition will be start on 45sec) 2. 6x25m MS on 60sec- competition start maximum speed to 15m to 20m (Each repetition will be start on 60sec) 3. 6x25m MS on 45sec- (explode the first and last 15m on alternate 25m repeats (Each repetition will be start on 45sec) 4. 6x25m MS on 60sec- competition start maximum speed to 15m to 20m (Each repetition will be start on 60sec) 5. 3x50m MS as 15m fast, 35m easy swim (Each repetition will be start on 2min) 6. 3x50m MS 20m fast, 30m easy swim (Each repetition will be start on 2min) Total-35min
Recovery	400m easy swim-10min

3.6. CRITERION MEASURES

1. MOTOR FITNESS VARIABLES		
Variables	**Tests /Tools Administered**	**Unit of Measurement**
1.1. Muscular strength		
1.1.a. Hand grip muscular strength (RH and LH)	Hand grip dynamometer (Sozen, 2012)	Kilogram (kg)
1.2. Muscular strength-endurance		
1.2.a. Arm and shoulder strength-endurance	Pull-ups (Sridhar & Giridharaprasath , 2017)	Number of push-ups (No)
1.2.b. Abdominal strength-endurance	Sit-ups (Lee & Oh, 2015)	Number of sit-ups (No)
1.3. Flexibility	Sit and reach test (Balaji & Murugavel, 2013)	Inches (inch)
1.4. Leg explosive strength	Standing broad jump (Yuksel, Cengiz, Zorba, & Gokdemir, 2015)	Meter (mt.)

2. ANTHROPOMETRICAL VARIABLES		
2.1.**Anthropometric measurements**		
Variables	**Tests /Tools Administered**	**Unit of Measurement**
2.1.1. Height	Anthropometric rod (Johnson & Nelson, 1982)	Centimeters (cm)
2.1.2. Weight	Digital weighing machine (Johnson & Nelson, 1982)	Kilogram (kg)
2.1.3. Shoulder width	Anthropometric rod (Kansal, 2008)	Centimeters (cm)
2.1.4. Chest circumference	Anthropometric tape (Kansal, 2008)	Centimeters (cm)
2.1.5. Arm span	Anthropometric tape (Kansal, 2008)	Centimeters (cm)
2.2.**Body composition Dimension**		

2.21. Body mass index	BMI (Kg/m^2) = $\frac{Weight\ in\ kg}{Height\ in\ meter2}$	Kg/m^2
2.2.2. Percentage of body fat	**% of Body Fat (%)** = (0.29288 x sum of skin folds) – (0.0005 x square of the sum of skin folds) + (0.15845 x age) – 5.76377 (Jackson & Pollock, 1985)	Percentage (%)
2.2.3. Total body fat	**Total Body Fat (kg)** = (%body fat/100) × total body mass (kg)	Kilogram (kg)
2.2.4. Lean body mass	**Lean Body Mass (kg)** = body mass (kg) – total body fat (kg)	Kilogram (kg)

3. PHYSIOLOGICAL & BIO-CHEMICAL VARIABLES		
3.1.**Hematological Variables**		
Variables	**Tests /Tools Administered**	**Unit of Measurement**
3.1.1. Red blood cell count	**Sysmex XP-100 Automatic hematology analyzer** **(**Sysmex corporation, Kobe, Japan) *Code No. A4466, Manufactured: April, 2016, Software version: Ver.* (Ghosh & Kundu, 2015; Varamenti, et al., 2013; Satoshi, et al., 2005) Analytical principle: WBC: DC detection method RBC/PLT: DC detection method HGB: Non-cyanide haemoglobin analysis method	$x10^6/\mu L$
3.1.2. White blood cell count		$x10^3/\mu L$
3.1.3. Platelets count		$x10^3/\mu L$
3.1.4. Hemoglobin concentration		g/dL
3.1.5. Hematocrit		%

Variables	**Tests /Tools Administered**	**Unit of Measurement**
3.2. Blood lactic acid accumulation	8x100 m Crawl Style Test (Agaoglu, et al., 2010) **Lactate Pro Analyzer** (Arkray Global Business, Inc, Kyoto, Japan), Serial No. 2601657 (Bonaventura, et al., 2015; Tanner, et al., 2010; Baldari, et al., 2009; Pyne, Boston, et al., 2000)	Mmol/L

4. PERFORMANCE RELATED VARIABLES		
Variables	**Tests /Tools Administered**	**Unit of Measurement**
4.1. 100m Swimming performance	100m freestyle (Shimonagata, Taguchi, & Miura, 2003)	Time (Sec)
4.2. Stroke rate	Stroke Rate = $\frac{60x3}{tSR}$ (Nugent, Comyns, Nevill, & Warrington, 2019)	cycle.m
4.3. Swim velocity	Swim velocity =$\frac{S}{t}$ (Karpinski, et al., 2019)	$m \cdot s^{-1}$
4.4. Stroke length	Stroke Length= $\frac{Vx60}{SR}$ (Patil, Salian, & Yardi, 2014)	m.cycle
4.5. Stroke index	Stroke Index = V x SL (Costill, et al., 1985)	m^2. (s. cycle)$^{-1}$

3.7. INSTRUMENT RELIABILITY

Instrument such as stop watches, skin fold caliper, hand grip dynamometer, sit and reach test box, digital weighing machine, anthropometric rod, non-stretchable tape, steel tape, hematological analyzer, lactate pro analyzer was used for this study. All instruments were made by reputed concerns and have been insured from the Department of Physical Education, Jadavpur University in good and working condition.

Their calibrations were accepted accurate enough to the serve purpose of the present study. Qualified assistance was made from professional technician from **Ayush Diagnostic & Polyclinic Lab**, Dhakuria Station Road, Kolkata, West Bengal, use of collecting hematological parameters.

3.8. SUBJECTS RELIABILITY

The subjects' reliability was established by test-reset method. Fifteen (15) junior swimmers were selected in the Nimpith Vivekananda sports Association, South 24 Parganas, west Bengal and they were tested twice by the same tester with the same instrument under the similar condition on each criterion parameters. The intra class co-efficient correlation was used to find out the subject's reliability with test-retest scores on each criterion parameters separately.

3.9. RELIABILITY OF DATA

Reliability of the data was established by test-retest method. Test-retest method was followed in order to establish the reliability of the data by using 5/15 subjects. All parameters were tested twice for the subjects by the same tester with same instrument under the similar conditions. The intra class co-efficient correlation was used to find out the reliability of the data and the results have been presented in following table.

Intra-class Coefficient of Correlation Values on selected Criterion Variables

Sl. No.	Variables	Co-efficient of Correlation 'r'
1. Motor Fitness Variables		
1.1.	Muscular strength	
1.1. a.	Hand grip muscular strength (RH) & (LH)	0.861* & 0.876*
1.2.	Muscular strength-endurance	
1.2. a.	Arm and shoulder strength-endurance	0.891*
1.2. b.	Abdominal strength-endurance	0.886*
1.3.	Flexibility	0.843*
1.4.	Leg explosive strength	0.887*

2. Anthropometrical Variables **2.1. Anthropometric Measurements**		
2.1.	Height	0.871*
2.2.	Weight	0.894*
2.3.	Shoulder Width	0.871*
2.4.	Chest Circumference	0.894*
2.5.	Arm Span	0.887*
2.2. Body Composition Dimension		
3.1.	Body mass index	0.856*
3.2.	Percentage of body fat	0.874*
3.3.	Total body fat	0.837*
3.4.	Lean body mass	0.887*
3. Physiological & Biochemical Variables		
3.1.	Hematological parameters	
3.1. a.	Red blood cell count	0.989*
3.1. b.	White blood cell count	0.987*
3.1. c.	Platelets count	0.988*
3.1. d.	Hemoglobin concentration	0.989*
3.1. e.	Hematocrit	0.979*
3.2.	Blood lactate level	0.985*

3.10. TESTER COMPETENCY

To ensure that the investigation was well versed in the techniques of conducting the tests, the investigator and his assistants had a number of practice sessions in the testing procedures. The test reliability was established by test and retest process. All the measurements were taken by the investigator with the assistance of Department of Physical Education, Jadavpur University, Kolkata and **Ayush Diagnostic & Polyclinic Lab**, Dhakuria Station Road, Kolkata, West Bengal. Care was taken that each test item was administered by the same person, so that reliable results could be ensured.

3.11. ADMINISTRATION OF TESTS

3.11.1. MOTOR FITNESS VARIABLES

3.11.1.1. Muscular Strength

3.11.1.1.a. Hand Grip Muscular strength (RH and LH)

Purpose: To measure the muscular strength of right and left-hand grip.

Equipment: Hand grip dynamometer and score sheet.

Procedure: The subject first dried the hand with chalk. The Hand grip dynamometer was adjusted and placed comfortably in the hand. The second joint (articulation) of the fingers had fitted snugly under the handle. The person assumed a standing position (using an upper cut portion) in a way so that the instrument was not being touched by the body or and another object. The person gave an all-out effort, statically contacting the muscles of hand, wrist and forearm for at least two to three seconds. The same process was repeated with the other hand.

Scoring: The person was given three trails, and best of taken as the score. The score was recorded to the nearest half kilogram.

3.11.1.2. Muscular Strength-Endurance

3.11.1.2.a. Arm and Shoulder Strength-Endurance (pull-Ups)

Purpose: To measure the muscular strength endurance of the arms and shoulder gridle.

Equipment: The equipment needed is a horizontal bar (one and half inches in diameter) raised to a height so that the tallest performer cannot touch the ground from the hanging position.

Procedure: The performer should assume the hanging position with the overhand (palms forward) and pull his body upward until the chin is over the bar. After each chin-up, the subjects should return to a fully extended hanging position. The pull-ups should be repeated as many times as possible.

Scoring: The score is the number of completed pull-ups is recorded.

3.11.1.2.b. Abdominal Strength-Endurance (Sit-Ups)

Purpose: To measure abdominal strength-endurance.

Equipment: Clean floor, stopwatch, score sheet and few assistants.

Procedure: The pupil lies on his back with his knees bent, feet on the floor and heels not more than 12 inches from the buttocks. The angle at the knees should be less than 90 degrees. The pupil puts his hands on the back of his neck with fingers clasped and places his elbows squarely on the floor. His feet are held by his partner to keep them in touch with the surface. The pupil tightens his abdominal muscles and brings his head and elbows forward as he curls up, finally touching elbows to knees. This action constitutes one sit-up. The pupil returns to the starting position with his elbows on the surface before he sits ups again. The timer gives the signal "ready-go," and the sit-up performance is started on the word "go." Performance is stopped on the word "stop." The number of correctly executed sit-ups performed in 60 seconds shall be the score.

Scoring: One point is scored for each correct sit-up. The score is the maximum number of sit-ups completed in 60 seconds.

3.11.1.3. Flexibility (Sit & Reach Test)

Purpose: To measure trunk flexion and ability to stretch back and thigh muscles.

Equipment: Sit & reach box, score sheet.

Procedure: The subject assumed a sitting position on floor with knees fully extended and toes of feet facing forward. The subject flexed the knees with arms fully extended and with hands placed on top of each other. Three trials will be given to each subject.

Scoring: A score the best of three trails was measured to the nearest quarter of an inch.

3.11.1.4. Leg Explosive Power (Standing Broad Jump)

Purpose: To measure the explosive strength of the legs.

Equipment: Outdoor jumping pit, measuring tape, score sheet and few assistants.

Procedure: Pupil stands with the feet several inches apart and the toes just behind the takeoff line. Preparatory to jumping, the pupil swings the arms backward and bends the knees. The jump is accomplished by simultaneously extending the knees and swinging forward the arms.

Scoring: The score is the distance between the take-off line and the nearest point where any part of the student's body touches the pit. It is measured in meters.

3.11.2. ANTHROPOMETRICAL VARIABLES

3.11.2.1. Anthropometric measurements

3.11.2.1.a Height

Purpose: To measure the stature of the subjects.

Equipment: Anthropometric rod, score sheet

Procedure: To measure the subject's standing height, the subject was asked to stand erect on the floor without shoes, by keeping the heels together, back and head touching the rod and looking straight.

Scoring: Height was recorded correct to the nearest centimeters.

3.11.2.1.b. Weight

Purpose: To measure the body weight of individual subject.

Equipment: Standard digital weighing machine, score sheet.

Procedure: The subjects were wearing the minimum clothing. The standard weighing machine used to measure body weight should be in an area, which is a smooth and even surface and with sufficient light, that the investigator in capable of properly recording the observation.

Scoring: The zero point of weighing machine checked often during the measurement was recorded. The weight of the subject's was recorded to the nearest kilogram.

3.11.2.1.c. Shoulder Width

Purpose: To measure the shoulder width of individual subject.

Equipment: Anthropometric rod, score sheet.

Procedure: The subjects stood erect with arms hanging side wise and weight evenly distributed on both legs. The measuring distance between left acromion to right acromion process was recorded from behind the neck.

Scoring: Shoulder width was recorded correct to the nearest centimeters.

3.11.2.1.d. Chest Circumference

Purpose: To measure the chest circumference of individual subject.

Equipment: Non- stretchable tape, score sheet.

Procedure: Subjects stand erect. The arms were raised while the tape was being adjusted and then lowered for the measurement. Measurer stood to in front to adjust the tape. Measurement was taken with tape passing over both the nipples, at normal respiration.

Scoring: Chest circumference was recorded correct to the nearest centimeters.

3.11.2.1.e. Arm Span

Purpose: To measure the arm span of the subjects.

Equipment: anthropometric tape.

Procedure: The subject assumes a relaxed standing position with the arms left and out stretched. This measurement represented the length of the arm span. The subject is standing away from the wall, with back and buttocks touching the arms are stretched out horizontally. Measurement was taken from the right of the dactylion to the left of the dactylion (middle finger).

Scoring: Arm span measurement of the subject was recorded as a score in centimeters.

3.11.2.2. Body Composition Dimension

3.11.2.2.a. Body Mass Index

Body mass index (BMI) was calculated by the following formula:

$$\textbf{BMI (Kg/m}^{2}\textbf{)} = \frac{\boldsymbol{Weight\ in\ kg}}{\boldsymbol{Height\ in\ meter2}}$$

3.11.2.2.b. Percentage of Body Fat

It was obtained by measuring skinfold thickness recorded in millimeters at four selected sites in the body namely, triceps, suprailiac, abdominal and thigh. Percentage body fat as estimated from the sum of skinfolds was calculated using equations by (Jackson & Pollock, 1985). Percent of Body fat was calculated by the following formula:

Body density= (0.29288 x sum of skin folds) – (0.0005 x square of the sum of skin folds) + (0.15845 x age) – 5.76377 (triceps, abdomen, suprailiac, thigh)

% of Body Fat =[(445/ body density) - 450]x 100

3.11.2.2.b.(I). Skinfold Measurement

The skinfold measurement consists triceps, suprailiac, abdominal and thigh sites. All the measurements recorded in millimetre (mm) and have been taken from right side of the subjects by the researcher himself. Skinfold was picked up at about one centimeter (cm) above the marked level, and value was noted after two seconds.

Measurement Techniques

Triceps skinfold: Triceps skinfold was measured over the triceps muscles parallel to the long axis of arm at side of the body mid-way between the acromion and elbow**.**

Suprailiac skinfold: Suprailiac skinfold was measured about one centimeter above and two centimeters medial to the anterior superior iliac spine.

Abdominal skinfold: Abdominal skinfold was measured at the three-centimeter lateral and one-centimeter inferior to center of the umbilicus.

Thigh skinfold: Thigh skin fold was measured about one centimeter at previously marked thigh on the anterior side.

3.11.2.2.c. Total Body Fat

Total Body Fat was calculated by the following formula:

Total Body Fat (kg) = (%body fat/100) × total body mass (kg)

3.11.2.2.d. Lean Body Mass

Lean body mass was calculated by the following formula:

LBM (kg) = body mass (kg) – total body fat (kg).

3.11.3. PHYSIOLOGICAL PARAMETERS

3.11.3.1. Hematological Parameters

Purpose: To assess hematological parameters

Equipment: Sysmex automated hematology analyzer, 10ml disposable syringe, niddles, blood container, anticoagulant (EDTA), tourniquet, cotton and methylated spirit were used for collecting and analyzing blood sample for each subject.

Procedure: The blood samples were taken in the morning between 7.00 am to 8.00 am. Blood samples from subjects were taken after 12 hours fasting and having refrained from vigorous exercise for at least 24 hours. The subjects were sat on arm chair. Examination of the superficial veins of the left forearm was made to select the vein for venous puncture. The skin was cleaned with spirit and allowed to dry. A tourniquet was tied around the upper arm. The subject was asked to flex and extend the wrist joint to make the veins more prominent. Thumb of the left hand was placed on the lower part of the cleaned area and gentle traction was given to fix the vein. As the vein was punctured, blood flowed in the syringe. A sterile cotton wool was placed on the punctured and pressed gently. About 5ml of blood was collected from each subject and captured in the anticoagulant (EDTA) tube. After the collecting data, analyzed with the help of **Ayush Diagnostic & Polyclinic Lab,** Dhakuria Station Road, Kolkata 700031.

3.11.3.2. Blood Lactic Acid

Objective: To measure the blood lactate levels.

Equipment: Lactate Pro Analyzer, strip, lancet, stopwatch.

Description: Blood lactate test protocol of 8x100m free-style distance was used in a 50m swimming pool. Two days before testing the participants performed a 100m swim at their maximum speed using the front crawl stroke. The training loads were determined by the results of 100m of swimming performance as the participants swim

100m at 75%, 85%, 90%, 95% and 100% of maximum speed for the distance (as determined previously). Resting blood lactate values and heart rate were obtained prior to the warm-up of each testing session.

For the first test, subjects performed a swimming session of 1000m, three times at 75% workload with one-minute rest intervals. Then, they rested for three minutes after the third set and blood samples were drawn at the 2^{nd} and 3^{rd} minutes of this resting period.

At the second test, subjects performed a swimming session of 100m, two times at 85% workload with one-minute rest intervals. They rested for four minutes after final set. Blood samples were drawn at the 3^{rd} and 4^{th} minutes of this testing period.

At the third test, subjects performed a swimming session of 100m, one time at 90% workload, and rested for six minutes blood samples were drawn between the 4^{th} and 5^{th} minutes of this resting period.

At the fourth test, subjects performed a swimming session of 100m, one time at 95% workload and rested then rested 25 minutes. Blood samples were drawn between the 5^{th} and 6^{th} minutes of this period.

At the fifth test, subjects performed swimming session of 100m, one time at 100% workload, then rested for 25 minutes. Blood samples were drawn between the 5^{th} and 6^{th} minutes of this period.

The blood samples were obtained from each participant's fingertip. Blood lactate concentration was measured through **Lactate Pro Analyzer (Arkray Global Business, Inc, Kyoto, Japan).**

3.11.4. PERFORMANCE RELATED PARAMETERS

3.11.4.1. 100m Swimming Performance

Purpose: To assess the swimming performance of the subjects.

Equipment: Stop watch, assistants, scoresheet.

Procedure: The test was carried out after two days of rest. Testing was conducted in a 50m swimming pool. Prior to the experiment, the swimmers performed a standard warm-up (600-800m), after warm-up each swimmer rested until reaching the subjective state of readiness for performing effort at maximum intensity. The subjects were divided into 5 batches consisting of 3 members. The starts were performed from stationary lying position, and hence there was push-off from the walls. the start was given by using the command ‘ready’ and whistle, with pushing-off from the wall the subjects swam using front crawl stroke at the maximum possible intensity over the distance. The watches were stopped and the timings were recalled from the memory for recording.

Scoring: The time taken to cover 100 meters distance was recorded in seconds.

3.11.4.2. Swim Velocity

The swim velocity was recorded distance by time taken to complete race and expressed in ($m \cdot s^{-1}$).

Swim velocity $=\frac{S}{t}$ (S= distance, t = time)

3.11.4.3. Stroke Rate

The time required to performed 3 stroke cycle was measured and the expressed in (cycle.m)

Stroke Rate $= \frac{60x3}{tSR}$ (tSR= time taken of 3 stroke cycle)

3.11.4.4. Stroke Length

The stroke length or distance per stroke was calculated by dividing the velocity by the stroke expressed in (m.cycle).

Stroke Length$= \frac{Vx60}{SR}$ (v = swim velocity, SR = stroke rate)

3.11.4.5. Stroke Index

The index (SI) was defined by (Costill, et al., Energy expenditure during front crawl swimming: predicting success in middle-distance events, 1985) as the product of average velocity and stroke length and they considered it a valid indicator of swimming efficiency. The resulting units were $m^2. (s. cycle)^{-1}$.

Stroke Index = V x SL (V = velocity, SL = stroke length)

3.12. STATISTICAL PROCEDURE ADOPTED FOR ANALYSIS OF THE DATA

The following statistical techniques were adopted to treat the collected data in connection with established hypotheses and objectives of the study.

1. Shapiro-Wilk Normality test was applied for check the normal distribution of the data.
2. Mean and standard deviations was computed for each variable separately and are presented in tabular form in the chapter-IV.
3. For comparison among the means of a variable within the group Analysis of Variance (One-Way ANOVA) was applied. Wherever the F-ratio was found significant, Least Significant Difference (L.S.D) Post Hoc test was applied.
4. Pearson Product-Moment Correlation coefficient was applied to find out the relationship of swimming performance, to each of these variables separately.

For the purpose of the present study, the level of significance was set up at 0.01 and 0.05 level of confidence which was deemed reasonable for the study.

Chapter-IV

Results and Discussion

4. Introduction

4.0. Normality Test of data

4.1. Personal Data

4.2. On Motor Fitness Variables

4.3. On Anthropometric Variables

4.4. On Physiological & Biochemical Variables

4.5. On Performance Related Variables

4.6. On Correlation Study

4.7. Testing of Hypotheses

CHAPTER-IV

RESULTS AND DISCUSSIONS

4. Introduction

The data collected according to the procedure mentioned in the **chapter-III** and are presented in this chapter adopting standard statistical procedures. The results are presented in tabular forms as well as graphical forms. The data gathered from three ‘states’ are marked as A1 (before the start of the training programme), A2 (after 12 weeks of training) and A3 (after completion of 24 weeks of training programme) respectively.

The Mean, SD, SE of all the parameters of the experimental group is presented first. The results of Analysis of Variance (One-Way ANOVA) among the different means of three ‘states’ of the experimental group are indicated duly. To mark the significant difference among the means of three ‘states’ Least Significant Difference (L.S.D) Post Hoc test was computed and presented along with the ‘F’ value.

Level of Significance

The Level of significance to check Analysis of Variance (One-Way ANOVA) for means was set at 0.01 and 0.05 level of confidence, which was considered as appropriate and adequate for the propose of this study.

Results are presented & discussed under four broad headings - 1. Motor fitness variables 2. Anthropometric variables 3. Physiological & biochemical variables and 4. Performance related variables. Each parameter is being discussed under three states - pre-training, after 12 weeks of training and after completion of 24 weeks of training.

4.0. Normality Test of data

Table no. 1. Results of normality test of dada

Parameters	**Pre-test**	**Mid-test**	**Post-test**
Hand grip muscular strength (RH)	0.59	0.69	0.23
Hand grip muscular strength (LH)	0.42	0.15	0.24
Arm and shoulder strength-endurance	0.12	0.28	0.30
Abdominal strength-endurance	0.26	0.68	0.71
Flexibility	0.64	0.59	0.46
Leg explosive strength	0.23	0.15	0.16
Height	0.14	0.13	0.14
Weight	0.34	0.86	0.84
Shoulder width	0.94	0.76	0.72
Chest circumference	0.18	0.30	0.22
Arm span	0.56	0.54	0.57
Body mass index	0.60	0.33	0.43
Percentage of body fat	0.94	0.76	0.72
Total body fat	0.17	0.54	0.39
Lean body mass	0.84	0.82	0.99
Red blood cell count	0.96	0.21	0.15
White blood cell count	0.98	0.43	0.65
Hemoglobin concentration	0.79	0.53	0.12
Platelets count	0.72	0.20	0.88
Haematocrit	0.15	0.73	0.17
Before onset of training	0.28	0.29	0.68
BLA end of 75% Workload	0.22	0.18	0.32
BLA end of 85% Workload	0.17	0.16	0.78
BLA end of 90% Workload	0.20	0.44	0.17
BLA end of 95% Workload	0.24	0.33	0.19

Parameters	**Pre-test**	**Mid-test**	**Post-test**
BLA end of 100% Workload	0.33	0.24	0.67
100m swimming performance	0.07	0.09	0.06
Swim velocity	0.06	0.07	0.08
Stroke rate	0.10	0.14	0.12
Stroke length	0.67	0.47	0.37
Stroke index	0.63	0.53	0.63

Table1 shows that the whole dada was normally distributed in the present study

4.1. Personal Data

Table: 2 Mean. SD & Range of Personal Data of the young swimmers

Parameters	**Training states**	**Mean**	**Standard Deviation**	**Min.**	**Max.**
Age (years)	A_1	15.21	0.77	14.00	16.00
Height (cm)	A_1	166.06	3.86	166.00	174.00
Weight (kg)	A_1	53.62	2.44	50.40	57.80

The mean, SD and range of age and height were presented in **Table no 2.** It appears from the table that the mean age of the subjects was 15.21±0.77 years, the mean height of the subjects was 166.06±3.86 cm and the mean weight of the subjects was 53.62± 2.44 kg.

4.2. Motor Fitness Variables

To measure the motor fitness dimension several tests for specific fitness parameters have been considered and the results of the test are presented duly.

4.2. 1. Muscular Strength

4.2.1.a. Hand Grip Muscular Strength (RH)

Hand grip muscular strength is a measure of strength of several muscles in the hand and the forearm. Hand grip can be quantified by measuring the amount of static force that the hand can squeeze around an instrument called as hand grip strength dynamometer. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 3 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Right-Hand Grip Muscular Strength (kg) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	31.52	4.15	1.07	26.20	40.50
A_2	15	33.67	4.20	1.08	27.60	42.90
A_3	15	35.85	3.89	1.00	31.50	44.60

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	140.835	70.418	**4.22***	.021
Within Groups	42	700.991	16.690		
Total	44	841.826			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

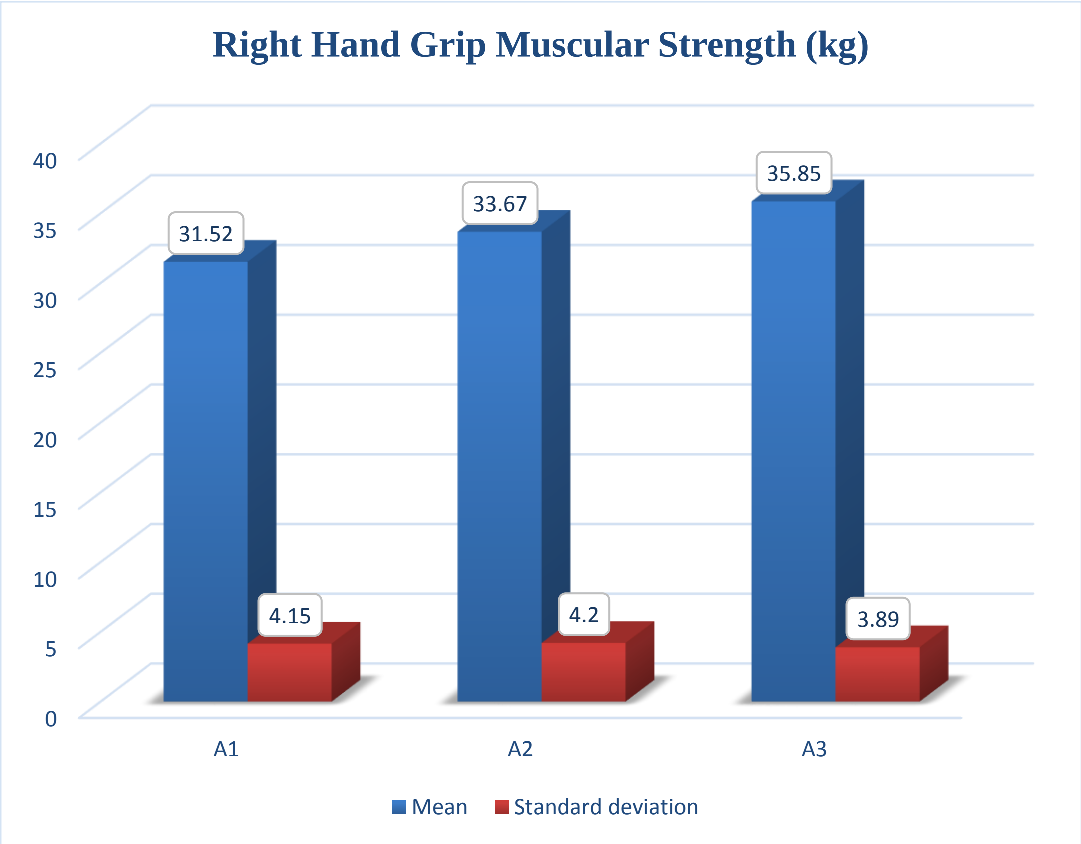
Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	-2.15	2.99	**4.22***
A_2 - A_3	-2.18		
A_1 - A_3	-4.33*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 3** shows that the mean right-hand grip muscular strength score at three training states for experimental group was **31.52 ± 4.15, 33.67 ± 4.20** and **35.85 ± 3.89** respectively. The results also may be evident in the **Fig no. 1.** It has been observed that in the experimental group following training right hand grip muscular strength score was improved markedly. From the analysis of variance (one-way ANOVA) it appears that the mean score of A1, A2, and A3 were unequal and the variance was significant (**F= 4.22**). Critical difference was calculated to find the exact difference among the means A1, A2, and A3.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD -4.33 was higher than CD at 0.05, 2.99. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no-1 Graphical representation among the means of three training states of Right-hand grip muscular strength (kg) of young swimmers



4.2.1.b. Hand Grip Muscular Strength (LH)

Table: 4 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Left-Hand Grip Muscular Strength (kg) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	30.60	4.19	1.08	25.20	39.60
A_2	15	32.62	4.05	1.04	27.80	40.80
A_3	15	34.93	4.23	1.09	30.30	42.20

One-way ANOVA:

Training state	Df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	141.048	70.524	**4.07***	.024
Within Groups	42	727.397	17.319		
Total	44	868.446			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

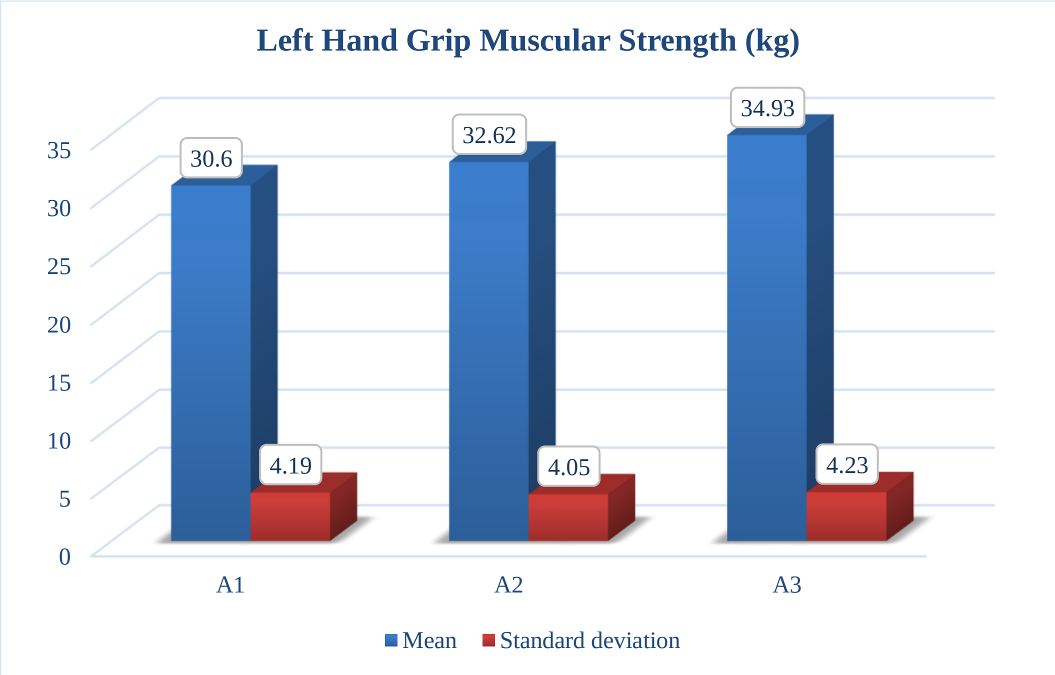
Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	-2.02	3.03	**4.07***
A_2 - A_3	-2.31		
A_1 - A_3	-4.33*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 4** shows that the mean left hand grip muscular strength score at three training states for experimental group was **30.60 ± 4.19, 32.62 ± 4.05** and **34.93 ± 4.23** respectively. The results also may be evident in the **Fig no. 2.** It has been observed that in the experimental group following training left hand grip muscular strength score was improved markedly. From the analysis of variance (one-way ANOVA) it appears that the mean score of A1, A2, and A3 were unequal and the variance was significant (**F= 4.07**). Critical difference was calculated to find the exact difference among the means A1, A2, and A3.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD -4.33 was higher than CD at 0.05, 3.03. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 2 Graphical representation among the means of three training states of Left-hand grip muscular strength (kg) of young swimmers



Discussion on Muscular Strength (Hand Grip Muscular Strength)

From the analysis of the results of muscular strength test, it appears that the specific program of dry-land strength-endurance and swimming training had profound influence on hand grip muscular strength (RH & LH) and was improved significantly. The magnitude of improvements was almost identical for both the hands of the subjects after training.

It may be said above that muscle adaptions are specific to the type of training performed and physical exercises, not only affects the muscles but also affects the neural mechanism of the muscles. Large and fast motor units are recruited only at the higher forces and it is possible during maximal voluntary contraction. Training as way of facilitating the recruitment of these large and fast motor units. The pattern of electrical stimulation of the motor units may change. Electrical stimulation of muscles through motor nerve or peripheral branches, requires frequencies of around 50-100 Hz to generate maximum tetanic force (Sale, 1988). This nerve path ways in which neural adaptions occurred, increased perhaps the maximum voluntary isometric strength. Recent research related to training for muscular strength indicated course of training for strength upliftment a maintenance program should be commenced to sustain the gains in muscular strength.

Research reports have indicated convincingly that muscular strength increased significantly following specific trainings (Grant & Kavaliauskas, Land Based Resistance Training and Youth Swimming Performance, 2017). Previous research reports have particularly found development in hand grip muscular strength performance following training program (Saygın & Ozturk, 2011; Dhara, Manna, Khanna, 2015; Manna, Khanna, & Dhara, 2012). Therefore, the findings of the present study are in consonance with others researchers. The impact of training is earmarked to the method in which the training is conducted. The effects of training are directly related to the activity planned as a training stimulus.

On the other hand, Dey, Jana, & Bandyopadhyay, (2015), Lee & Oh, (2015), Unveren, Cengiz, & Karavelioglu, (2013), Sozen, (2012) have found no significant improvement in hand grip muscular strength following specific training.

Therefore, from the analysis of the results of the present study and from the findings of the other researchers it may safely be concluded that for the improvement of the muscular strength performance specific training is needed and that too for a considerable period of time.

4.2.2. Muscular Strength-Endurance

4.2.2.a. Arm and Shoulder Strength-Endurance (Pull-Ups)

Pull-ups are a suitable and feasible fitness test and have hugely been used by sports related professionals. The test measures the dynamic strength-endurance of shoulder girdle. The specific training programmed employed had specific movement of the muscles of this region and the total work done with the load, details of which have been given in **chapter-III**, perhaps influenced the muscles as may be seen from the results.

The subjects underwent the training program and had sit-ups as one the items in the training program. The effect of this training with overload principles perhaps impacts the sit-ups test performance as may be evident from the results.

Table: 5 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Arm and Shoulder Strength Endurance (number of pull-ups) of young swimmers

Descriptive Statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	11.33	3.73	.96	6.00	18.00
A_2	15	13.26	3.78	.97	8.00	20.00
A_3	15	15.40	3.97	1.02	10.00	23.00

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	124.133	62.067	**4.22***	.021
Within Groups	42	617.867	14.711		
Total	44	742.000			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

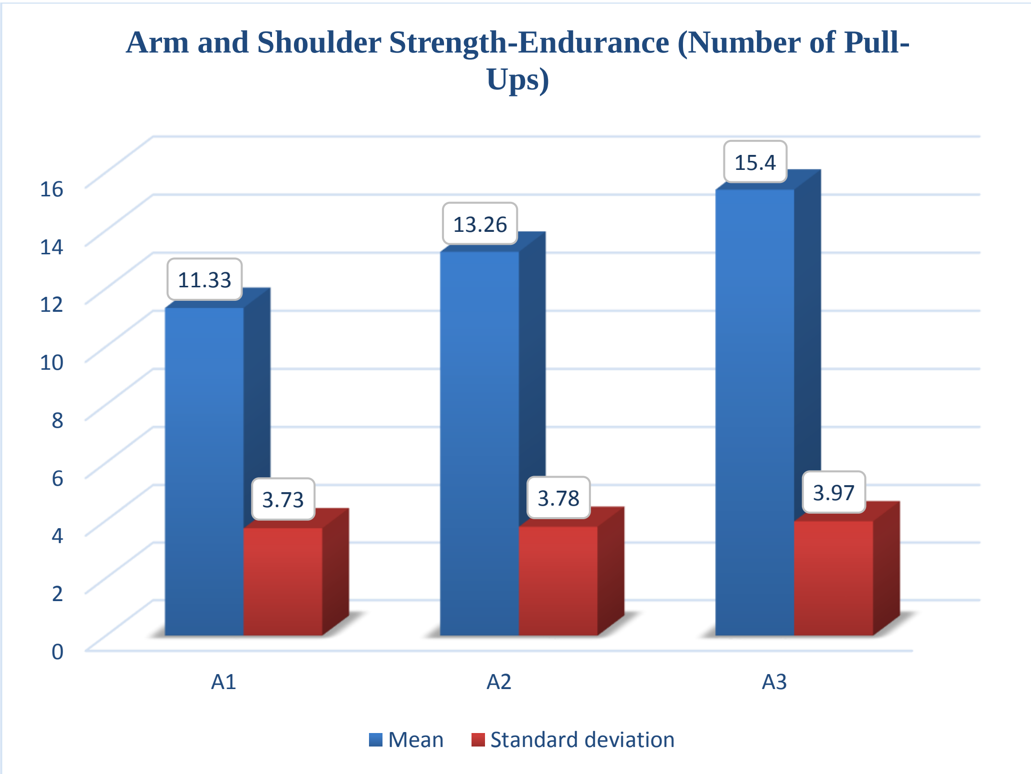
Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-1.93	2.81	**4.22***
$A_2 - A_3$	-2.13		
$A_1 - A_3$	-4.06*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

Table no. 5 shows that the mean arm and shoulder strength-endurance score at three training states for subjects was **11.33 ± 3.73, 13.26 ± 3.78** and **15.40 ± 3.97** respectively. The results are also presented in graphical form in **Fig no. 3.** It appears from the table that the variation of arm and shoulder strength-endurance for experimental group during three training states were significant. After calculation of analysis of variance (one-way ANOVA) among the three means the observed F-value was **4.22.** Since, the F-value was significant, critical difference was calculated to find the exact difference among the means A1, A2, and A3.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD -4.06 was higher than CD at 0.05, 2.81. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 3 Graphical representation among the means of three training states of Arm and Shoulder Strength-Endurance (number of pull-ups) of young swimmers



4.2.2.b. Abdominal Strength-Endurance (Sit-Ups)

Strength and endurance are abdominal muscles are important in promoting good posture and correct pelvic alignment. This test item is the famous for physical education professionals. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

The subjects underwent the training program and had sit-ups as one the items in the training program. The effect of this training with overload principles perhaps impacts the sit-ups test performance as may be evident from the results.

Table: 6 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Abdominal Strength-Endurance (number of sit-ups) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	45.20	4.09	1.05	40.00	53.00
A_2	15	47.13	4.13	1.06	41.00	55.00
A_3	15	49.80	4.14	1.06	44.00	58.00

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	160.044	80.022	**4.70***	.014
Within Groups	42	714.533	17.013		
Total	44	874.578			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

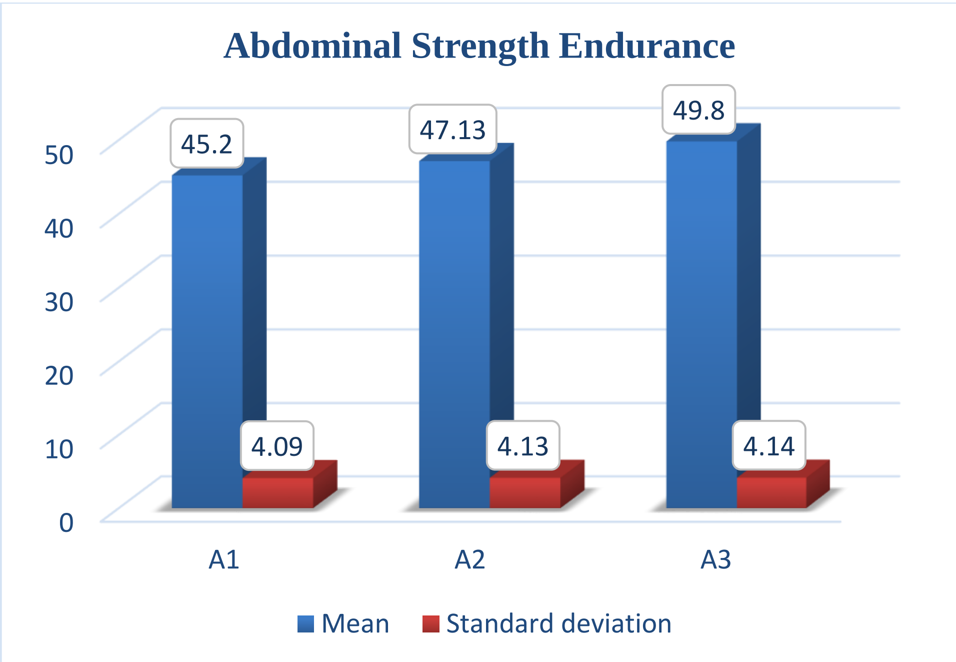
Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	-1.93	3.01	**4.70***
A_2 - A_3	-2.66		
A_1 - A_3	-4.60*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

Table no.6 shows that the mean arm and shoulder strength-endurance score at three training states for experimental group was **45.20 ± 4.09, 47.13 ± 4.13** and **49.80 ± 4.14** respectively. The results are also presented in graphical form in **Fig no. 4.** It appears from the table that the variation of arm and shoulder-strength endurance for the subjects during three training states were significant. After calculation of analysis of variance (one-way ANOVA) among the three means the observed F-value was **4.70.** Since, the F-value was significant, critical difference was calculated to find the exact difference among the means A1, A2, and A3.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD -4.60 was higher than CD at 0.05, 3.01. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 4 Graphical representation among the means of three training states of Abdominal Strength-Endurance (number of sit-ups) of young swimmers



Discussion on Muscular Strength-Endurance (pull-ups, sit-ups)

Muscular strength is a product of skeletal muscles contraction caused by neuro-muscular system. In various sports movements strength always appears in some combination with duration and speed of movement, while strength combines with speed abilities it is explosive strength, on the other hand strength in combination with endurance ability forms the strength-endurance ability. It is the ability to overcome resistance or to act against resistance under conditions of fatigue. In all sports movements, whether fast or slow, movements have to be done under lesser or higher conditions of fatigue. To improve strength-endurance capacity therefore, requires a program where it is indispensable to overcome a comparatively high resistance for a reasonable period of time. It simply means selection of sufficient load (over load) with repetition between 15 to 20 is required.

The physiological changes by which strength-endurance improves is a combination of adaptation of muscle and tissue characteristics as well as enzyme activity in mitochondria. The training stimulus signals mRNA by which the muscles fiber gets the sequence for the production of more tropomyosin and enzyme protein. Nervous system is also stimulated by strength-endurance, so the prohibition is decreased and at the same time more efficient and skilled movements conserve energy, thereby contributing strength-endurance (Holloszy & Coyle, 1984)

Research reports have indicated convincingly that muscular strength-endurance improved significantly following specific training. Sarkar & Das (2018), Lesinski et. al. (2017), Manske et al. (2015), Wakene et al. (2015), Balaji & Murugavel (2014), Marques et al. (2008), Das (1995) have found significant improvement in strength-endurance different games and sports training program. Grant & Kavaliauskas (2017), Tsourlou et al. (2006) have indicated that significant improvement occurred in strength-endurance performance following swimming training program. On the other hand, Lee & Oh, (2015) found no significant improved of muscular strength-endurance in their study.

In the training program for the subjects of the present study for the first to 24 weeks contained a number of weight training exercises as well as sit-ups and pull-ups exercises which meant for development of strength-endurance. Accordingly, the results revealed that following training programs strength-endurance, as evident from muscular strength-endurance (pull-ups and sit-ups tests) has significantly been improved in the subjects. It is expected that the training load was sufficient to elicit the adaptation, stated above, and the performance has improved in selected test items. The conclusion from the present analysis may be drawn by stating that in sports performance, strength-endurance is essential by adopting adequate program specifically sustain the gain in strength-endurance for reasonable period of time, depending on the objectivity of the training program.

4.2.3. Flexibility (Sit and Reach Test)

Flexibility refers to the range of movement in a joint or series of joints, and length in muscles that cross the joints to induce a bending movement or motion. In the field of sports and games flexibility is a pre-requisite for maximum development of movement force and speed. Good flexibility helps in achieving higher movement economy. Flexibility is indispensable for prevention of injuries since the stability of a joint is maximum when flexibility is optimum. Flexibility is joint specific and dependent number of factors, such as anatomical alignment of the joint, stretchability of muscles, conditions of the ligaments, strength and coordinative ability and also temperature, massage, warm-up, time of the day etc. sit and reach test is a common test for measurement of hip-trunk flexibility and ability to stretch hamstrings muscles. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 7 Descriptive statistics; ANOVA among the means of three training states and L.S.D of flexibility (inches) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	15.11	1.86	.48	12.02	19.02
A_2	15	16.38	1.83	.47	13.03	20.00
A_3	15	17.03	1.98	.51	13.02	20.06

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	28.528	14.264	**3.97***	.026
Within Groups	42	150.931	3.594		
Total	44	179.459			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-1.26	1.44	**3.97***
$A_2 - A_3$	-.64		
$A_1 - A_3$	-1.91^{*}		

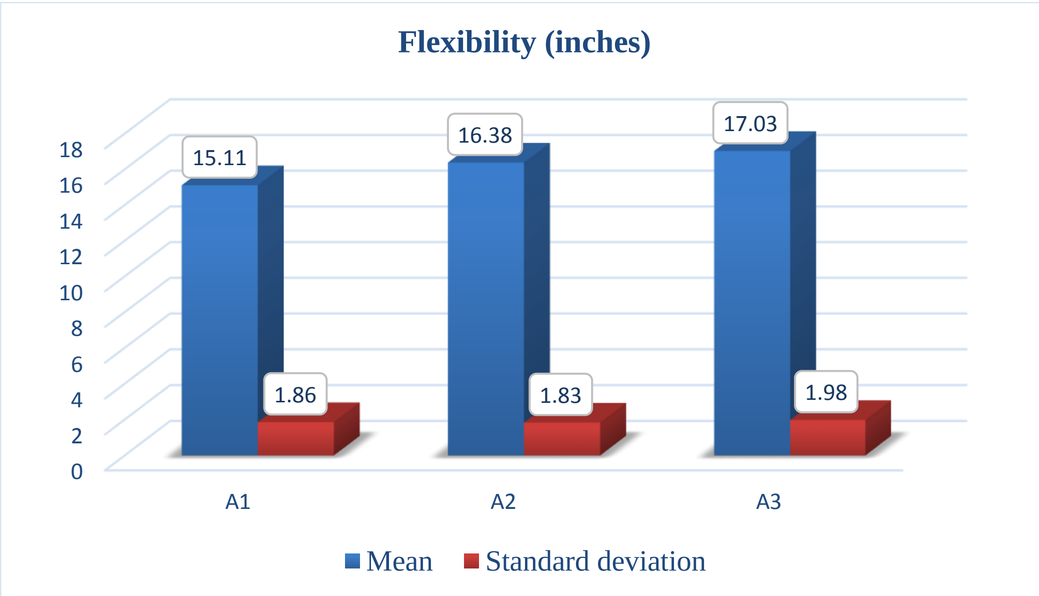
A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

Table no. 7 shows that the mean flexibility score at three training states for experimental group was **15.11 ± 1.86, 16.38 ± 1.83** and **17.03 ± 1.98** respectively. The results are also presented in graphical form in **Fig no. 5.** It appears from the table that the variation of flexibility for experimental group during three training states (A1, A2, A3) were significant (**F= 3.97)**. The required F value to be significant (at 0.05 level) was 3.22.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD -1.91 was higher than CD at 0.05, 1.44. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 5 Graphical representation among the means of three training states of Flexibility (inches) of young swimmers



Discussion on Flexibility (Sit and Reach Test)

Human muscles are covered by tuff connective tissue which is a major restriction to the range of motion, as are the joint capsule and tendons. specific stretching exercises and increased muscle and joint temperatures increase flexibility. Stretching gradually leads to minor distensions in connective tissue and summation of these small changes can dramatically improve the range of motion. Fox & Mathews (1981) have mentioned that flexibility can be improved through appropriate training but it is very specific to the joint involved and the type of stretching exercise. Moreover, it is specific to the sports skill and aids the performance.

From the present study flexibility was significantly increased after specific training program. Similar results were found from the finding of the other research reports (Sridhar & Giridharaprasath, 2017; Wakene et al. 2015; Saygın & Ozturk, 2011; Silva, et al., 2017; Godara, 2016; Das, 1995). Grant & Kavaliauskas, (2017), (Tsourlou et al. (2006) have indicated that significant improvement in hip-trunk flexibility performance following swimming training program. On the other hand, Bandyopadhyay et al. (2015), Lee & Oh, (2015) has reported no changes in flexibility after specific training program.

Research reports have indicated that development of flexibility is very specific to the joint, type of exercise program and physical capabilities. Therefore, the findings of the present study on flexibility measure are not unusual. It may therefore be concluded that flexibility may be improved through specific training programs.

4.2.4. Leg Explosive Strength (Standing Broad Jump)

Leg explosive power is the ability of an individual to release the maximum force in the shortest possible time. The product of strength and speed of muscular contraction is the power and the standing broad jump is a classical test for the measurement of this ability. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 8 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Leg Explosive Strength (meters) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	1.91	.11	.03	1.78	2.15
A_2	15	1.97	.11	.02	1.84	2.20
A_3	15	2.03	.11	.02	1.90	2.23

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	.102	.051	**3.84***	.029
Within Groups	42	.559	.013		
Total	44	.661			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-.05	0.08	**3.84***
$A_2 - A_3$	-.06		
$A_1 - A_3$	-.11*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

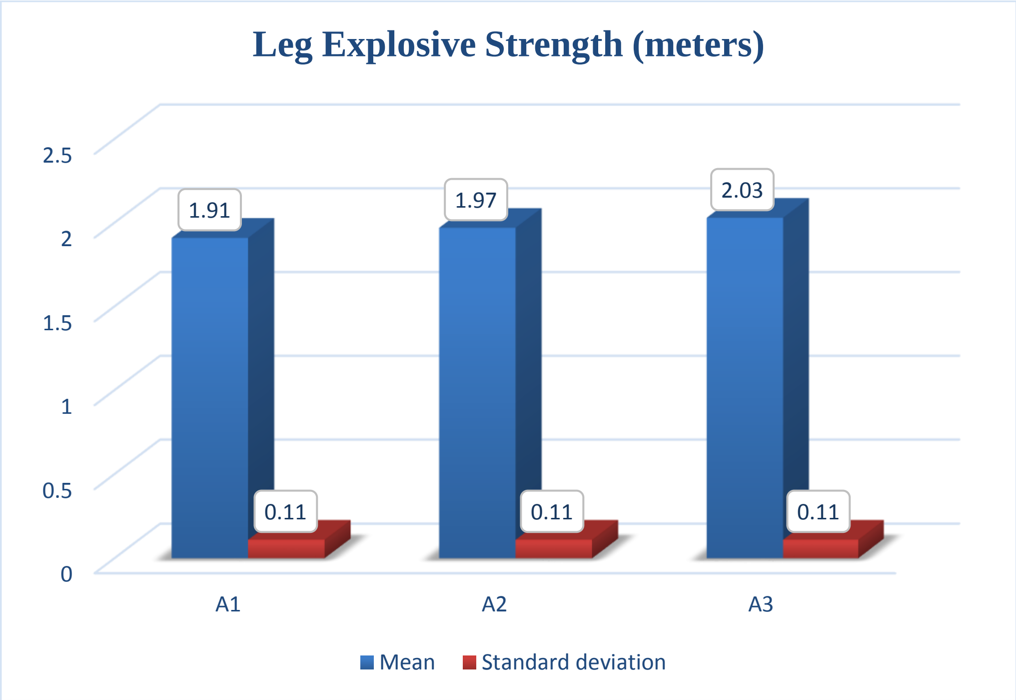
In **Table no. 8** showed that the mean and standard deviation values at the three training states for leg explosive strength of experimental group were **1.91 ± .11, 1.97 ± .11** and **2.03 ± .11** respectively.

The application of analysis of variance (one-way ANOVA) in **Table no**. **8** shows that the F- value of **3.84** is statistically significant as it is greater than table value of $F_{.05}$

(2,44) = 3.21, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD -.11 was higher than CD at 0.05, 0.08. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 6 Graphical representation among the means of three training states of Leg Explosive Strength (meter) of young swimmers



Discussion on Leg Explosive strength (Standing Broad Jump)

The result of this analysis indicated that leg explosive strength improved significantly during the training period. Primary gain in muscle strength during initial few weeks of training do not show a concomitant gain in muscle size or muscle cross sectional area. The quality of the muscles- specially, type of the muscle proteins that make of the myosin filament changes but not enough protein in accumulated in the cell to create increase in muscle fiber size. Within several weeks, however, myosin proteins start to be added to muscle fiber, and increases in muscle fiber size are shown at about eight to twelve weeks of training (Viru & Viru, 2001). The reason for that strength training improves force production of the skeletal muscle trained. The increased force production is accompanied by an increased in muscle cross sectional area of the muscle and fast-twitch fiber area, along with increases in muscle contractile protein. However, other factors modify the strength, such as neural factors, internal muscle structure, limb length and joint architecture. The muscle fiber composition is not critical in isometric contractions, but when contraction is performed at high velocities, a high percentage of fast twitch fibers are advantageous. In the primary stage of training program, strength increase more rapidly than the muscle mass. Gradually, there is a muscle hypertrophy, more so if the training load is at maximum or close to maximum. The increase in muscle mass in attributable to an increase in the cross-sectional area of the individual muscle fibers by the formation of more myofibrils. The number of muscles fibers does not seem to change, but the percentage of type IIA increases at the expenditure of type IIX (Matsuda, et al., 1986).

The result of the study indicated that leg explosive strength increased significantly during the specific training period. Similar results were observed from the findings of the various research reports, that leg explosive strength was improved through different type of training methods (Yuksel et al, 2015; Debnath & Ezhilmaran, 2016; Savucu, 2012; (Marques et al. 2008). Sarkar & Das, (2018) has reported that 2% and 1.96% improved in explosive power due to specific training program. Kemp & Pienaar (2009) has mentioned that ten-weeks specific training programme, while twice a week, with a thirty minutes duration and an intensity level of 55 - 70% heart rate max an improved leg explosive strength. Any resistance-based training program should optimize the development of key performance variables, including, muscular strength, explosive power and core stability (Grant & Kavaliauskas, Land Based Resistance Training and Youth Swimming Performance, 2017).

The conclusion from the present analysis may be drawn by stating that in sports performance, leg explosive strength is essential by adopting adequate program specifically sustain the gain in leg explosive power for reasonable period of time, depending on the objectivity of the training program.

4.3. Anthropometric Variables: Anthropometric variables considered in this study was consists of -1. anthropometric measurements, 2. Body composition dimension.

4.3.1. Anthropometric Measurements

Anthropometry can simply be defined as the study of human body measurements and the physical variations found among humans. When applied to swimming, some athletes possess certain physical variations besides height that give them an advantage in the pool. For instance, swimmers with long wingspans have a definite advantage, as they are able to reach farther and pull more water with every stroke. Limb length and body size play a huge role in event potential, and the relationship between arm length and height gives a better picture of the athlete's potential. Swimmers with a high anthropometry score-that is, their arms are relatively long in relation to their height tend to do best in the long-axis strokes of freestyle.

4.3.1.a. Height (cm)

Hight of an individual plays an important role in his motor abilities. Height is mist obvious physical factors that give swimmers a distinct advantage in the pool. Greater height results in longer stroke length, which is turn may lead to improved performance in swimming. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 9 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Height (cm) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	166.06	3.86	.99	161	174
A_2	15	166.16	3.76	.97	161.10	174
A_3	15	166.76	3.78	.97	166. 15	175

One-way ANOVA:

Training state	Df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	4.214	2.107	**.14**	.865
Within Groups	42	607.743	14.470		
Total	44	611.956			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-.10	2.77	**.14**
$A_2 - A_3$	-.59		
$A_1 - A_3$	-.69		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

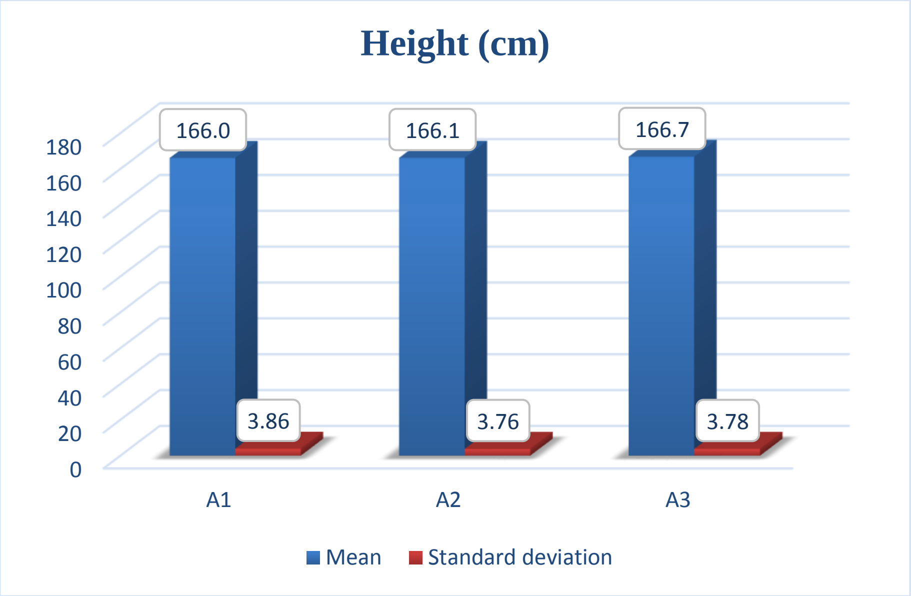
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 9** showed that the mean and standard deviation values at the three training states for height of experimental group were **166.06 ± 3.86, 166.16 ± 3.76** and **166.76 ± 3.78** respectively. The results are also presented in graphical form in **Fig no. 7**.

The application of analysis of variance (one-way ANOVA) in **Table no 9**. shows that the F- value of **.14** is statistically insignificant as it is lesser than table value of $F_{.05}$ (2,42) = 3.22, thus indicating insignificant differences among the three training states.

Through F- value were not significant even then critical difference also calculated to find the difference the three training states of means of experimental group. The obtained critical difference between insignificant (at 0.05 level) was 2.77 for experimental group and the difference between any two set of mean scores of the group was lower than required value. Probable these low mean differences were responsible for insignificant F- value.

Fig no- 7 Graphical representation among the means of three training states of Height (cm) of young swimmers



Discussion on Height

The result of the analysis indicated that height was increased insignificantly during the specific training period. Previous some results were observed from the findings of the various researchers while, these research studies have reported insignificant increased height through following training program (Temur et al., 2017; Strzala & Tyka, 2007; Dey, Jana, & Bandyopadhyay, 2015; Wakene, Bussa, & Mekonnen, 2015; Khanna, Manna, & Dhara, 2011; Stachowicz, Milde, & Janik, 2011; Wong, et al., 2008).

On the other hand, Ferreira, et al. (2019), Turgay, et al. (2019), Grant & Kavaliauskas, (2017), Morais, et al. (2016), Rodrigues-Ferreira, et al. (2015) have found height was significant increased following training program.

In the present analysis also insignificant increase in height of the subjects. From the findings of the present analysis, it may be concluded that, height was slightly increased due to physiological growth of the subjects, may not be due to specific training program.

4.3.1.b. Weight (kg)

Body weight is one of the important indicators of general health and physique and can play a role in sports training. Therefore, the influence of training on the body weight has been studied by many leading researchers and also in the present study too. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 10 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Weight (kg) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	53.62	2.44	.63	50.40	57.80
A_2	15	52.45	2.33	.60	48.30	56.50
A_3	15	51.12	2.56	.66	47.00	55.80

One-way ANOVA:

Training state	Df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	46.944	23.472	**3.92***	.027
Within Groups	42	251.485	5.988		
Total	44	298.430			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	1.16	1.78	**3.92***
A_2- A_3	1.33		
A_1 - A_3	2.50*		

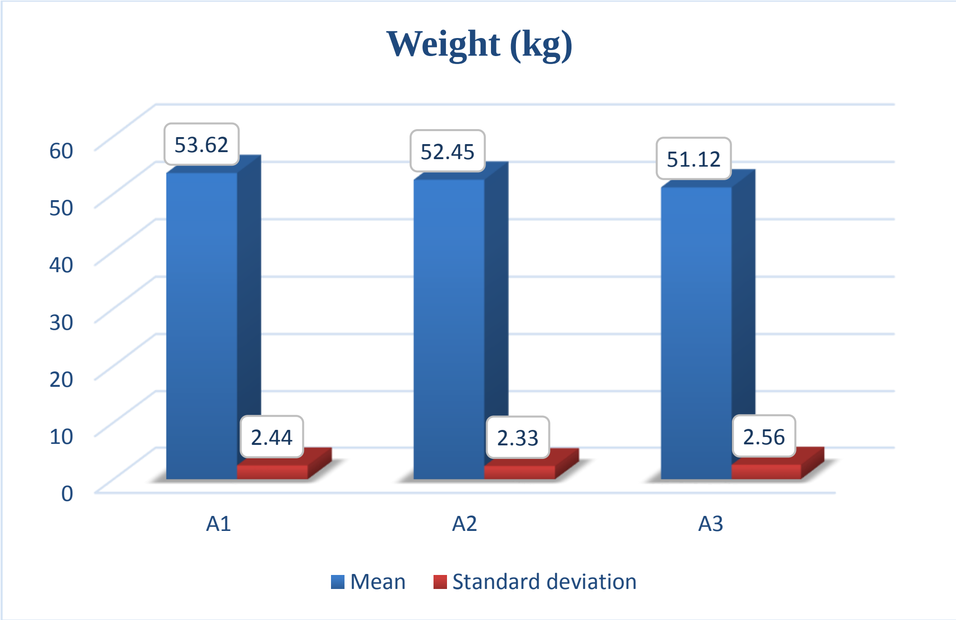
A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

Table no. 10 shows that the mean weight score at three training states for experimental group was **53.62 ± 2.44, 52.45 ± 2.33** and **51.12 ± 2.56** respectively. The results are also presented in graphical form in **Fig no. 8**. It appears from the table that the variation of body weight for subjects during three training states (A1, A2, A3) were significant **(F= 3.92)**. The required F value to be significant (at 0.05 level) was 3.22.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD 2.50 was higher than CD at 0.05, 1.78. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 8 Graphical representation among the means of three training states of Weight (kg) of young swimmers



Discussion on Weight

The result of the study indicated that weight was decreased significantly during the specific training period. During exercise training energy comes from our muscle's ability to break down fat and carbohydrate (stored within the muscle, liver, and fat tissue) with the help of oxygen. So, during exercise, heart beats faster and heart works harder to pump more oxygen to exercising muscles. After exercise fatigue leads to more oxygen and energy required over a prolonged period to repair damaged muscle and replenish depleted energy stores. As such loses excess fat due to the high calorie cost of the actual training session (Hottenrott, Ludyga, & Schulze, 2012).

Regarding effect of training on weight change may be observed among the researchers while, Lesinski, et al., (2017), Roelofs, et al., (2017), Morais, et al., (2016), Rodrigues-Ferreira, et al., (2015), Strzala & Tyka, (2007) have found significant increase of body weight following training program.

Some studies consistent with present study, Charmas & Gromisz, (2019), Turgay, et al., (2019), Cicek, (2018), Grant & Kavaliauskas, (2017), Pilch, et al., (2017), (Temur, et al., (2017), Skrypnik, et al., (2015), Zahedmanesh, Zafari, & Zahedmanesh, (2013), Koc, et al., (2012), Das, (1995) have found significant decrease in body weight following training program.

On the other hand, Bandyopadhyay, et al., (2015), Dhara, Manna, & Khanna, (2015), Yuksel, et al., (2015), Erdemir, Okmen, & Savucu, (2013), Wong, et al., (2008), have found no change in body weight following training program.

In the present study also decrease in body weight was observed in experimental group. From the findings of the present analysis, it may guess that, body weight may be altered due to effect of training, depending on the nature of the training characteristics.

4.3.1.c. Shoulder Width (cm)

Table: 11 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Shoulder Width (cm) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	41.79	1.99	.53	38.25	45.41
A_2	15	42.39	2.05	.50	38.40	46.32
A_3	15	43.13	1.97	.51	39.31	46.93

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	13.459	6.729	**1.67**	0.20
Within Groups	42	169.1407	4.027		
Total	44	182.6001			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-.60	1.47	**1.97**
$A_2 - A_3$	-.76		
$A_1 - A_3$	-1.36		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

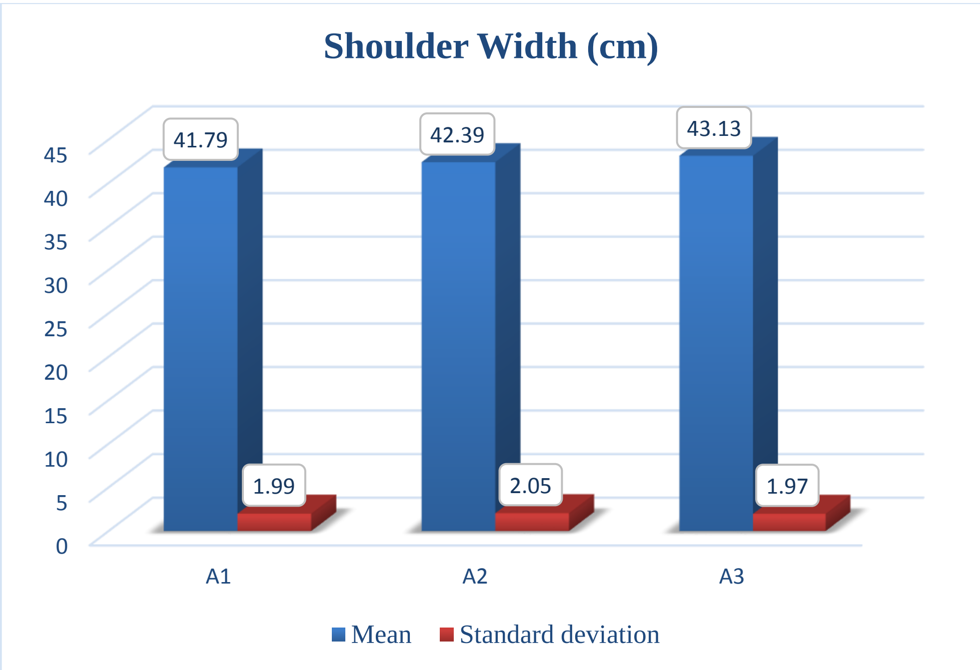
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 11** showed that the mean and standard deviation values at the three training states for shoulder width of experimental group were **41.79 ± 1.99, 42.39 ± 2.05** and **43.13 ± 1.97** respectively. The results are also presented in graphical form in **Fig no. 9**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **11** shows that the F- value of **1.67** is statistically insignificant as it is lesser than table value of $F_{.05}$ (2,42) = 3.22, thus indicating insignificant differences among the three training states.

Through F- value were not significant even then critical difference also calculated to find the difference the three training states of means of experimental group. The obtained critical difference between insignificant (at 0.05 level) was 1.47 for experimental group and the difference between any two set of mean scores of the group was lower than required value. Probable these low mean differences were responsible for insignificant F- value.

Fig no- 9 Graphical representation among the means of three training states of Shoulder width (cm) of young swimmers



Discussion on shoulder width

The result of the study indicate that shoulder width was no significantly increased during the specific training period. Swimmers had significantly greater shoulder width compared non-overhead athletes after twelve weeks of swimming training (Hibberd, et al., 2016; Batalha, et al., 2021). The training intensity in competitive swimming is very challenging, with the shoulder girdle requiring considerable muscular endurance because the upper extremities provide the large majority of the propulsive force (Pink & Tibone, 2000), excessive repletion of overhead movements and cumulative years of swimming training changes of shoulder girdle (Heinlein & Cosgarea, 2010; Higson, Herrington, Butler, & Horsley, 2018). Swimmers are notorious for having broad shoulders and a rounded posture. The muscles in the shoulder and upper back are hypertrophied from repetitive motion.

In present study shows no significant differences in shoulder width values. From the findings, of the present study and reviewing the research reports relating to shoulder width, it may be concluded that shoulder width was changed due to influence of specific training, depending on a considerable period of time.

4.3.1.d. Chest Circumference (cm)

Table: 12 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Chest Circumference (cm) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Range	
A_1	15	82.52	3.30	.85	78.73	88.25
A_2	15	83.88	3.17	.82	79.85	89.39
A_3	15	85.48	2.96	.76	81.38	90.30

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	65.709	32.854	**3.31***	.046
Within Groups	42	417.146	9.932		
Total	44	482.855			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	-1.35	2.66	**3.31***
A_2 - A_3	-1.59		
A_1 - A_3	-2.95*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

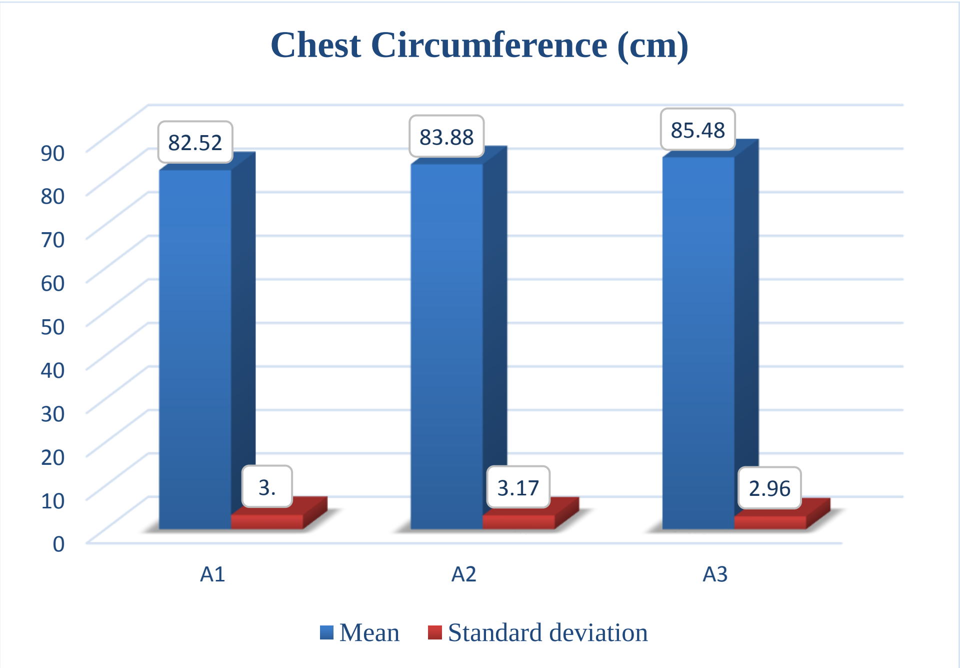
$F_{(2, 44)}$ = 3.21 is significant at the 0.05 level

Table no. 12 shows that the mean chest circumference score at three training states for experimental group was **82.52 ± 3.30, 83.88 ± 3.17** and **85.48 ± 2.96** respectively. The results are also presented in graphical form in **Fig no. 10**.

It appears from the table that the variation of chest circumference for experimental group during three training states (A1, A2, A3) were significant (**F= 3.31)**. The required F value to be significant (at 0.05 level) was 3.22.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD 2.95 was higher than CD at 0.05, 2.66. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 10 Graphical representation among the means of three training states of Chest Circumference (cm) of young swimmers



Discussion on Chest Circumference

The result of the study indicate that chest circumference significantly increased during the specific training period. Swimming imposes unique challenges upon the developing respiratory system; first, it is performed in the prone or supine position with the body partially or fully submerged (Cordain & Stager, 1988); second, swimmers use an “obligatory, controlled frequency” breathing pattern (Cordain & Stager, 1988): third, training often involves breath control drills, including “hypoxic training”, and sprint swimming where breathing frequency is reduced; and, fourth, intense and structured swim training begins as early as 5 years old (Baxter-Jones & Helms, 1996). Instead, the greater total lung capacity (TLC) of swimmers may have been related to larger chests (Hsia, et al., 2004; Dempsey, 1986). Normal lung development occurs via a feedback loop between rib cage and alveolar growths (Hsia, et al., 2004), such that chest wall and lung growths are tightly coupled and their dimensions reach peak growth velocities at similar times (Simon , Tanner, Benjamin, Reid, & Goldstein, 1972). Bloomfield, Blanksby, & Ackland, (1990) expressed in their study on adolescent swimmers that, there was significant difference in chest girth before and after training and Zinman & Gaultier, (1986) found greater chest wall dimension in pubescent swimmers than their counterparts. Temur, et al., (2017) examined the effect of eight weeks exercise and found significantly increased in chest circumference. Kaplan, (2016), Stachowicz, Milde, & Janik, (2011) stated in studies on adolescent children, that there was significantly improved in chest circumference after sixteen weeks swimming training.

In present study also significantly differences in chest circumference values. From the findings, of the present study and reviewing the research reports relating to chest circumference it may be concluded that chest circumference was changed due to influence of specific training, depending on a considerable period of time.

4.3.1.e. Arm Span (cm)

Table: 13 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Arm Span (cm) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	190.70	6.64	1.71	180.05	199.18
A_2	15	191.12	6.51	1.68	180.44	199.55
A_3	15	191.95	5.90	1.52	183.08	199.65

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	12.181	6.091	**.15**	.861
Within Groups	42	1701.046	40.501		
Total	44	1713.227			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-.42	2.77	**.15**
$A_2 - A_3$	-.82		
$A_1 - A_3$	-1.25		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

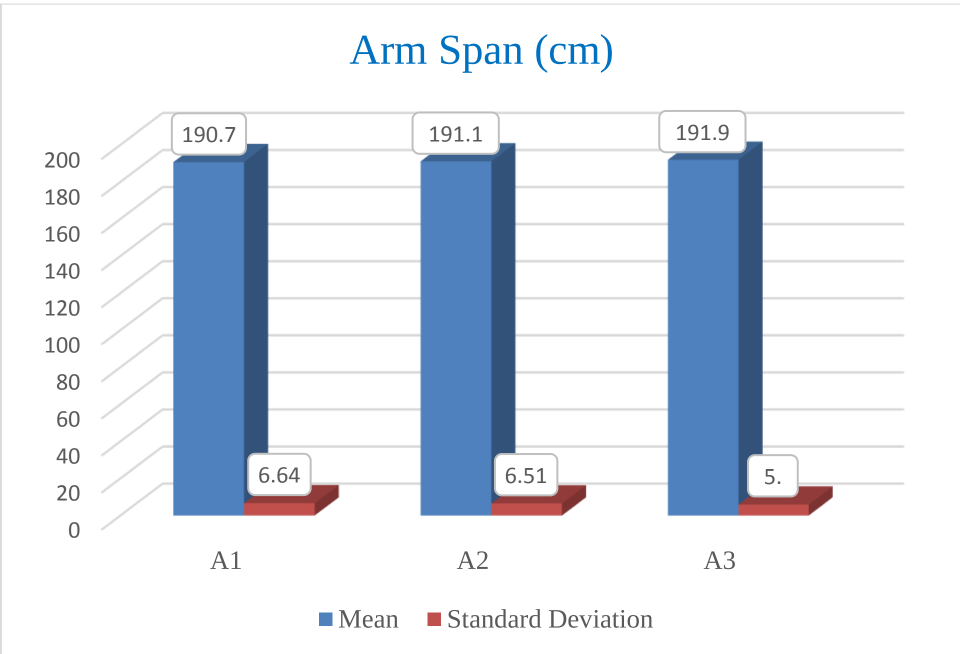
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 13** showed that the mean and standard deviation values at the three training states for height of experimental group were **190.70 ± 6.64, 191.12 ± 6.51** and **191.95 ± 5.90** respectively. The results are also presented in graphical form in **Fig no. 11**.

The application of analysis of variance (one-way ANOVA) in **Table no. 13** shows that the F- value of **.15** is statistically insignificant differences as it is lesser than table value of $F_{.05}$ (2,42) = 3.22, thus indicating insignificant differences among the three training states.

Through F- value were not significant even then critical difference also calculated to find the difference the three training states of means of experimental group. The obtained critical difference between insignificant (at 0.05 level) was 2.77 for experimental group and the difference between any two set of mean scores of the group was lower than required value. Probable these low mean differences were responsible for insignificant F- value.

Fig no- 11 Graphical representation among the means of three training states of Arm Span (cm) of young swimmers



Discussion on Arm Span

The result of the present study indicated that arm span was statistically no significantly increased during the specific training period. Present findings are in contrast with, Strzala & Tyka, (2007) who detected a statistically significant increment of arm span after half-year specific training program in competitive swimmers. (Morais, et al. (2016) verified a significant increase in the arm span of competitive swimmers who took part in a 40-weeks specific concurrent water and dry-land training sessions.

From the findings, of the present study and reviewing the research reports relating to arm span it may be concluded that arm span may be changed due to influence of specific training, depending on a nature of training and considerable period of time.

4.3.2. Body composition Dimension

Body composition is the proportion of the lean body mass and depot fat, and it is one of the most important morphological features characterizing human organism. It is an important index of fitness and in sports and games it may play a crucial role. Therefore, body mass index, percentage of body fat, total fat weight and lean body mass have been taken up specially for observing the training effect on the experimental group of the study.

4.3.2.a. Body mass index

A measurement of the amount of body fat and lean body mass. It is calculated by dividing a person's weight in kilograms by their height in meters square. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 14 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Body Mass Index (Kg/m^2) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	19.42	1.35	.35	17.31	21.81
A_2	15	18.93	1.11	.28	17.10	20.49
A_3	15	18.85	1.07	.27	17.10	20.46

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	2.876	1.438	**1.01**	0.37
Within Groups	42	59.577	1.418		
Total	44	62.453			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	.48	0.86	**1.01**
$A_2 - A_3$	.08		
$A_1 - A_3$	.57		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

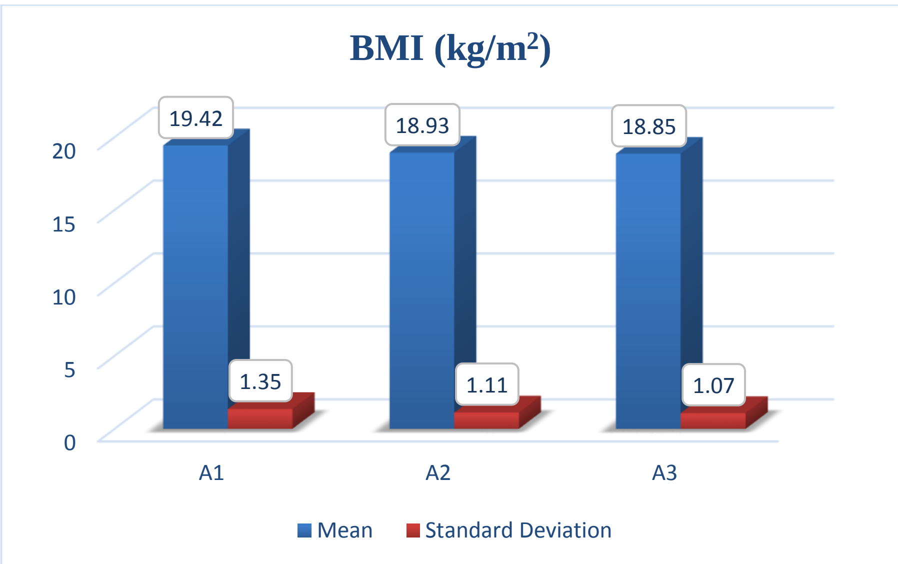
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 14** showed that the mean and standard deviation values at the three training states for body mass index of experimental group were **19.42 ± 1.35, 18.93 ± 1.11** and **18.85 ± 1.07** respectively. The results are also presented in graphical form in **Fig no. 12**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **14** shows that the F- value of **1.01** is statistically insignificant as it is lesser than table value of $F_{.05}$ (2,42) = 3.22, thus indicating insignificant differences among the three training states.

Through F- value were not significant even then critical difference also calculated to find the difference the three training states of means of experimental group. The obtained critical difference between insignificant (at 0,05 level) was 0.86 for experimental group and the difference between any two set of mean scores of the group was lower than required value. Probable these low mean differences were responsible for insignificant F- value.

Fig no- 12 Graphical representation among the means of three training states of Body Mass Index (Kg/m^2) of young swimmers



Discussion on Body Mass Index

The result of the study indicated that body mass index found no significant change during the specific training period. Regarding effect of training on body mass index change observed among the researchers while, Wakene, Bussa, & Mekonnen, (2015) expressed in their study BMI significant increase after specific high intensity training program. Kostrzewa-Nowak, et al., (2015) have found significantly increased in body mass index following long-term aerobic training program.

Many research reports indicated that different specific training program helping reduction of BMI (Cicek, 2018; Temur, et al., 2017; Skrypnik, et al., 2015; Zahedmanesh, Zafari, & Zahedmanesh, 2013; Regaieg, et al., 2013; Koc, et al., 2012; Saygın & Ozturk, 2011; Wong, et al., 2008).

On the other hand, Charmas & Gromisz, (2019), Turgay, et al., (2019), Grant & Kavaliauskas, (2017) found no significant change after specific swimming training program. Many other research reports have found no significant changes in body mass index following training program (Pilch, et al., 2017; Dey, Jana, & Bandyopadhyay, 2015; Rodrigues-Ferreira, et al., 2015; Erdemir, Okmen, & Savucu, 2013; Hottenrott, Ludyga, & Schulze, 2012; Stachowicz, Milde, & Janik, 2011). In the present analysis also no significant change in body mass index was observed in experimental group.

Analyzing the data of the present study and reviewing the leading research reports it may safely be concluded that body mass index following training may change positively, negatively or no change, depending on a nature of training and considerable period of time.

4.3.2.b. Percentage of body fat (%)

An appropriate appraisal of body fat provides a significant basis of formulated an in knowledgeable program of fitness. Body weight alone does not show the factual illustration of the body constitution, since over weight and over fat are not synonymous excess fat percentage have a definite effect on quality of motor performance. For this reason, assessment of fat percentage has been considered as an index of fitness in this study and accordingly training effect was assessed and analyzed. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 15 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Percentage of body fat (%) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	15.61	2.01	.52	11.57	18.77
A_2	15	14.69	2.08	.53	10.63	17.82
A_3	15	13.41	2.05	.52	10.00	16.82

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	36.580	18.290	**4.34***	0.01
Within Groups	42	176.703	4.207		
Total	44	213.283			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	.91	1.50	**4.34***
$A_2 - A_3$	1.27		
$A_1 - A_3$	2.19*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

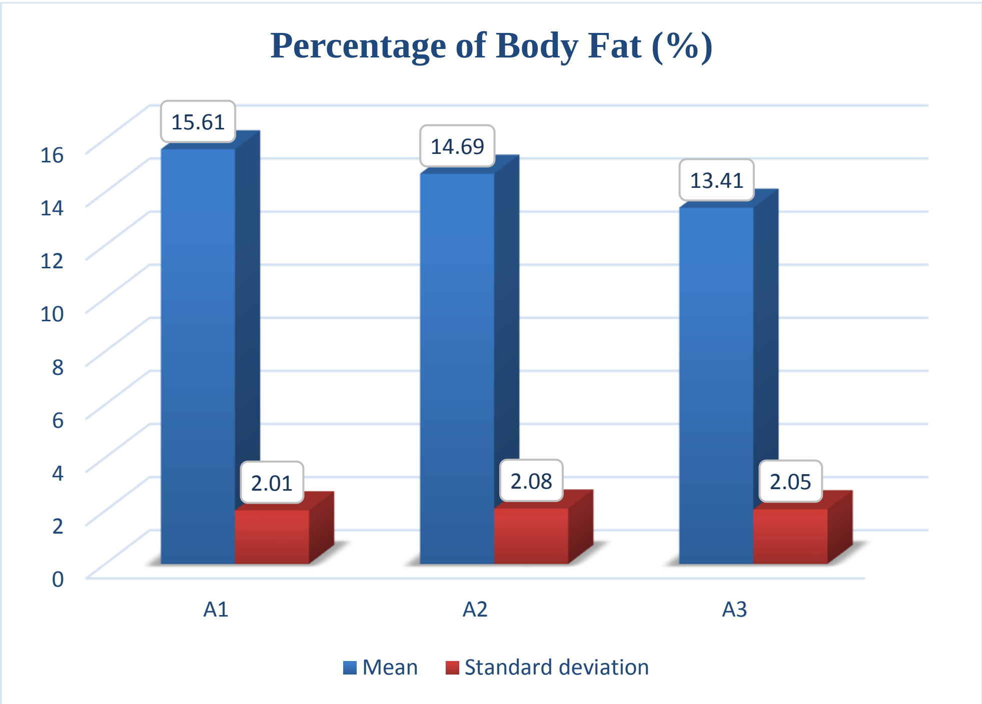
In **Table no. 15** showed that the mean and standard deviation values at the three training states for percentage of body fat of experimental group were **15.61 ± 2.02, 14.69 ± 2.08** and **13.41 ± 2.05** respectively. The results are also presented in graphical form in **Fig no. 13**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **15** shows that the F- value of **4.34** is statistically significant as it is greater than table value of $F_{.05}$

(2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD 2.19 was higher than CD at 0.05, 1.50. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 13 Graphical representation among the means of three training states of Percentage of body fat (%) of young swimmers



Discussion on Percentage of Body Fat

The result of the study indicated that percentage of body fat decreased significantly during the specific training period. Regarding effect of training on percentage of body fat change observed among the findings while, Pilch, et al., (2017), Silva, et al., (2017), Dhara, Manna, & Khanna, (2015), Manna, Khanna, & Dhara, (2012), Koc, et al., (2012), Skrypnik, et al., (2015), Kostrzewa-Nowak, et al., (2015), Saygın & Ozturk, (2011), Das, (1995) have observed that to a significantly decreased in percentage of body fat though training require a systematic training for a considerable period of time. Lee & Oh, (2015), Arroyo -Toledo, et al., (2013), Zahedmanesh, Zafari, & Zahedmanesh, (2013), (Meleski & Malina, 1885)have found significantly decreased in percentage of body fat specific swimming training program. They were of the observation that a specific training program of three-four days a week with training intensity 60-70% of maximum heart rate and duration thirty-forty minutes program in a day is necessary to decrease the percentage of body fat significantly. During moderately strenuous exercise of intensity that can be maintained 90 minutes or longer (approximately 55-75% of vo_2 max), there is a progressive decline in the proportion of energy derived from muscle glycogen and progressive increase in plasma fatty acid oxidation (Holloszy, Kohrt, & Hansen, 1998). Fatty acids are the most abundant source of endogenous energy substrate. They can be mobilized from peripheral adipose tissue and transported via the blood to active muscles. During higher intensity exercise, triglyceride within the muscle can also be hydrolyzed to release fatty acids for subsequent direct oxidation, during exercise intensity increases, and fatty acid oxidation becomes approximately equal to the total amount of fatty acids available at 65% of VO_2 max. When plasma FFA concentration is increased by lipid infusion during exercise at 85% VO_2 max, fat oxidation is significantly increased (Wolfe, 1998).

In the present study the significant decrease of percentage of body fat exhibit that the training intensity was sufficient for reduction of percentage of body fat and may be imposed to the greater calorie burning effect of the training program.

4.3.2.c. Total body fat (kg)

Fat is the most variable tissue in the body and distributed throughout the body primarily under the skin and in the abdominal cavity. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 16 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Total body fat (kg) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	8.39	1.29	.33	5.83	10.04
A_2	15	7.72	1.25	.32	5.37	9.56
A_3	15	6.86	1.14	.29	4.80	8.62

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	17.603	8.802	**5.80***	0.00
Within Groups	42	63.700	1.517		
Total	44	81.303			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	.67	.90	**5.80***
A_2- A_3	.85		
A_1 - A_3	1.52*		

A_1 = pre-training state; A_2 =12^{th} weeks of training state; A_3 = 24^{th} week of training state

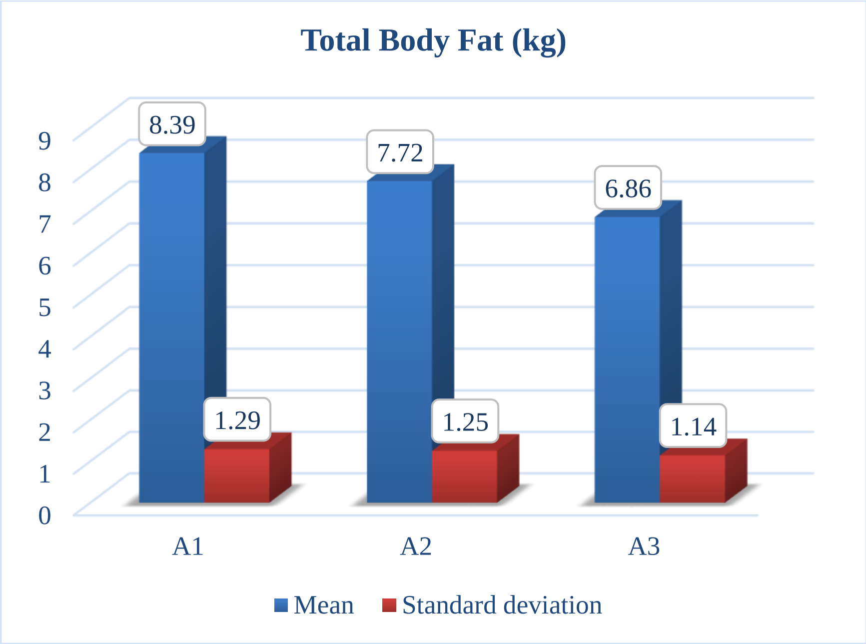
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 16** showed that the mean and standard deviation values at the three training states for total body fat of experimental group were **8.39 ± 1.29, 7.72 ± 1.25** and **6.86 ± 1.14** respectively. The results are also presented in graphical form in **Fig no. 14**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **16** shows that the F- value of **5.80** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD 1.52 was higher than CD at 0.05, 0.90. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 14 Graphical representation among the means of three training states of Total body fat (kg) of young swimmers



Discussion on Total Body Fat

The result of the study indicated that total body fat decreased significantly during the specific training period. Roelofs, et al., (2017), Lee & Oh, (2015) have found significantly increased in total body fat following training program. On the other hand, Charmas & Gromisz, (2019), Bandyopadhyay, et al., (2015), Erdemir, Okmen, & Savucu, (2013), Wong, et al., (2008), Vilamitjana, et al., (2006) found no significant change after 12-weeks swimming training program.

Reduction of total body fat following training have been observed by a number of researchers, Grant & Kavaliauskas, (2017), Pilch, et al., (2017), Skrypnik, et al., (2015), Kostrzewa-Nowak, et al., (2015), Arroyo -Toledo, et al., (2013), Regaieg, et al., (2013) have mentioned that to have a significantly decreased in total body fat through specific training require a systematic training for a considerable period of time. During exercise training energy comes from our muscle’s ability to break down fat and carbohydrate (stored within the muscle, liver, and fat tissue) with the help of oxygen. So, during exercise, heart breathe faster and heart works harder to pump more oxygen, fat and carbohydrate to exercising muscles. After exercise fatigue leads to more oxygen and energy required over a prolonged period to repair damaged muscle and replenish depleted energy stores. As such loses excess fat due to the high calorie cost of the actual training session.

In the present analysis also the significant reduction of total body fat indicates that training intensity was sufficient for reduction of total body fat and may be attributed to the greater calorie burning effect of the training program.

4.3.2.d. Lean Body Mass (kg)

The term lean body mass means fat free body weight but it contents a small percentage of essential fat stores, chiefly within the central nervous system, marrow of bones and internal organs. Another term 'fat free mass', refers to the body mass devoid of all extractable fat. In general terms both are almost synonymous. The lean body mass indicates how much muscle is available, since body weight alone does not tell enough about an individual's body composition. Lean body mass is also an important determining factor for performance ability of an athlete. Excess body fat is detrimental to performance in most sports whereas, fat free mass, especially muscle muss, is generally associated with performance. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 17 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Lean Body Mass (kg) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	45.22	1.79	.46	43.25	48.22
A_2	15	44.73	1.91	.49	41.59	48.22
A_3	15	44.25	2.27	.58	39.83	48.55

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	7.083	3.541	.88	.42
Within Groups	42	168.981	4.023		
Total	44	176.063			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	.49	1.47	**.88**
A_2 - A_3	.47		
A_1 - A_3	.97		

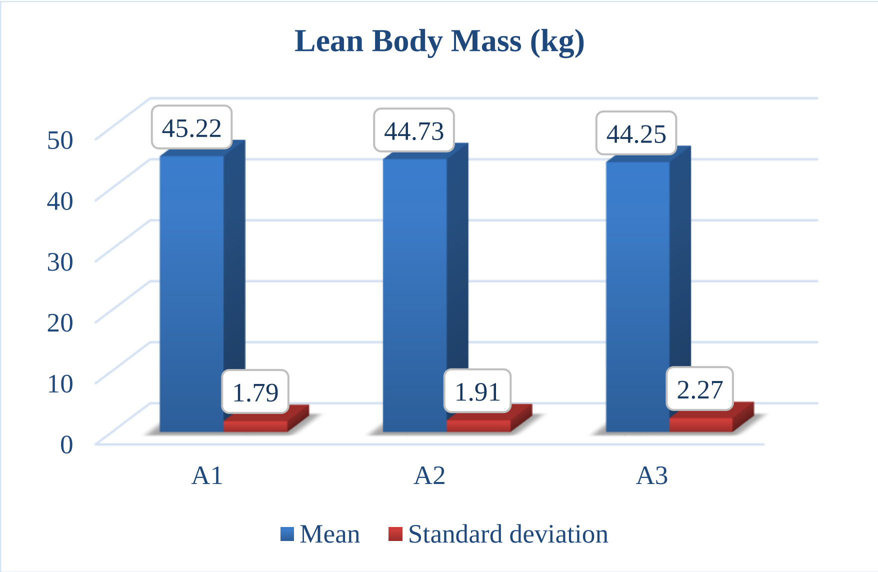
A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

Table no. 17 shows that the mean lean body mass score at three training states for experimental group was **45.22 ± 1.79, 44.73 ± 1.91** and **44.25 ± 2.27** respectively. The results are also presented in graphical form in **Fig no. 15.** It appears from the table that the variation of lean body mass for experimental group during three training states (A1, A2, A3) were insignificant **(F= .88)**. The required F value to be significant (at 0.05 level) was 3.22.

Through F- value were not significant even then critical difference also calculated to find the difference the three training states of means of experimental group. The obtained critical difference between insignificant (at 0.05 level) was 1.47 for experimental group and the difference between any two set of mean scores of the group was lower than required value. Probable these low mean differences were responsible for insignificant F- value.

Fig no- 15 Graphical representation among the means of three training states of Lean Body Mass (kg)of young swimmers



Discussion on Lean Body Mass

The result of the study indicated that lean body mass no significant change during the specific training period. Regarding effect of training on percentage of body fat change observed among the findings while, Lesinski, et al., (2017), Pilch, et al., (2017), Strzala & Tyka, (2007), Dhara, Manna, & Khanna, (2015), Khanna, Manna, & Dhara, (2011), Wong, et al., (2008) have found significantly increased in lean body mass following training program.

On the other hand, Charmas & Gromisz, (2019), Grant & Kavaliauskas, (2017) has found no significant change in LBM after specific training program of young swimmers. Roelofs, et al., (2017), Bandyopadhyay, Dey, Jana, & Ganguly, (2015), Lee & Oh, (2015), Skrypnik, et al., (2015), Arroyo -Toledo, et al., (2013), Hottenrott, Ludyga, & Schulze, (2012), Das, (1995) have observed that no changes in lean body mass following training program.

From the findings, of the present analysis and reviewing the research reports relating to lean body mass, it concluded that the effect of training on lean body mass is insignificant in children and adolescent but in case of adults, exercise training may have a significant influence on lean body mass.

4.4. Physiological & Biochemical Variables

Evaluation of basic physiological status has been considered a most momentous aspect of sports performance measurement of sportsperson and in exercise testing any test for the evaluation of the athletes or for fitness would be meaningless unless it is based on the sound physiological consideration. the functional condition of organs of the bodily systems should be studied at rest and during exercise. Exercise stress is a medium by which quantum of exercise load may be easily computed and optimum efficiency may be obtained. The physiological dimension was comprised of (i) hematological parameters, such as red blood cell count, white blood cell count, hemoglobin concentration, hematocrit, platelets count (ii) blood lactic acid at rest, during exercise measured in the present study.

4.4.1. Hematological parameters

Blood is a tissue. The essential act of blood is to maintaining of homeostasis of internal tissues of body. A lot of actions are done in the body which change the internal environment of chemical element, for example some alteration will occur by contraction of body muscles like others of body organs, blood does not give the same reaction to every physical exercise. Kind of physical exercise, intensity and duration are circumstances which body show effective reaction from itself.

Hematological parameters, such as hemoglobin, red blood cell and hematocrit have basic duty for transfer of oxygen for active tissues. Therefore, body capacity and Vo2 max is dependent on transferring of active oxygen to active tissues. Therefore, the importance of hematological parameters in providing of consumes oxygen in active tissues and consequently in body capacity is more shown. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

4.4.1.a. Red blood cell count (x10^6/µL)

Red blood cell known as red blood corpuscles or erythrocytes. It delivering oxygen to the active body tissues – via blood flow through the circulatory system.

Table: 18 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Red Blood Cell count (x10^6/µL) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	4.61	.31	.08	4.08	4.98
A_2	15	5.04	.48	.12	4.28	5.82
A_3	15	4.71	.45	.11	4.09	5.73

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	1.507	.753	**4.26***	.021
Within Groups	42	7.432	.177		
Total	44	8.938			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-.42*	.30	**4.26***
$A_2 - A_3$	.33*		
$A_1 - A_3$	-.09		

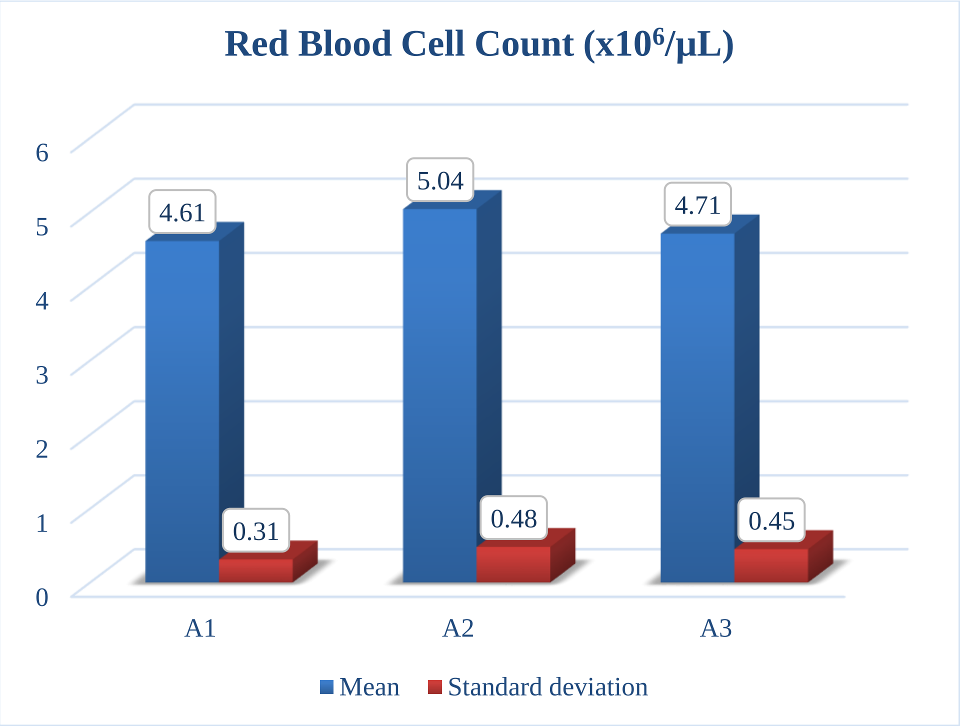
A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 18** showed that the mean and standard deviation values at the three training states for red blood cell count of experimental group were **4.61 ± .31, 5.04 ± .48** and **4.71** ± **.45** respectively. The results are also presented in graphical form in **Fig no. 16**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **18** shows that the F- value of **4.26** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

The above table reveals no significant difference only between A1 and A3 and other two mean differences (A1 and A2 and A2 and A3) were significant.

Fig no- 16 Graphical representation among the means of three training states of Red Blood Cell Count (x10^6/µL) of young swimmers



Discussion on Red Blood Cell count

The result of the study indicated that red blood cell counts significantly increased after twelve weeks and decreased after the end of twenty-four weeks, this variation was statistically significant. Similar variations in red blood cell count were observed in male athletes during their preparation to competition period (Bachero-Mena, et al., 2017; Bekris, et al., 2015). Some research reports consistent with present results, during their long-term swimming training (Manna & Khanna, 2013; Li, et al., 2012; Rushall & Busch, 1985; Santhiago, et al., 2009). During exercise the cardiovascular system has to warrant substrate supply to working muscle. The main function of red blood cells is the transport of O_2 from the lungs to the tissues and the delivery of metabolically produced CO_2 to the lungs for expiration. These functions require adequate amounts of red blood cells in circulation. The mechanisms that increase total red blood cell mass by training are not understood fully, despite stimulated erythropoiesis. Exercise can decrease the red blood cell mass by intravascular hemolysis mainly of senescent red blood cells, which is caused by mechanical rupture when red blood cells pass through capillaries in contracting muscles, and by compression of red blood cell (Mairbäurl , 2013).

Regarding effect of training on red blood cell change observed among the researchers while, Bijeh, et al., (2013) has observed that significantly increased in red blood cell of specific swimming training in sedentary subjects. Koc, et al., (2012) has examined blood biochemistry at before and after exercise training and observed that red blood cell increased depending on severity and duration of an exercise. Bezci & Kaya, (2010) found that RBC values was significantly enhanced in elite women taekwondoers before and after training.

Number of authors of reported that significantly decreased in RBC after different training. Nuviala, et al., (1992) have observed that swimmers can reduce the basic red blood cell parameters much more than other sports in both sexes and may be associated to a greater extent with sports anaemia. Savucu, (2012) stated that red blood cell values decreased after long-term training.

All early and late changes in the red blood cell after acute intensive physical exercise regardless of its characteristics are caused by factors associated mainly with the processes of hemoconcentration and hemodilution and with changes in the plasma catecholamine concentration (Satoshi, et al., 2005). Karakoc, Düzova, & Emre, (2005), Cicek, (2018) found that RBC significantly decreased after different exercise training. Turgay, et al., (2019) compared the blood samples of subjects before and after the specific swimming training session in their study on swimmers and determined that there was significantly decreased in red blood cell. In chronic daily physical activity, continuing for years, decreased in red blood cell parameter coexist with physical training (Kostrzewa-Nowak, et al., 2015).

The mechanisms involved are probably quite different: chronic intravascular hemolysis, which is associated with strength sports, and change in serum erythropoietin concentration.

From the findings, of the present analysis and reviewing the research reports relating to red blood cell it may be concluded that red blood cell count may be altered due to influence of exercise training, depending on the severity and duration of exercise training.

4.4.1.b. White blood cell count ($x10^3/\mu L$)

White blood cell also known as leukocytes, are the cells of the immune system that are involved in protecting the body against both infectious disease and foreign invaders.

Table: 19 Descriptive statistics; ANOVA among the means of three training states and L.S.D of White Blood Cell Count ($x10^3/\mu L$) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	7.52	1.12	.30	6.70	10.70
A_2	15	8.40	1.02	.27	6.70	10.90
A_3	15	7.58	1.13	.25	6.20	10.20

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	8.566	4.283		
Within Groups	42	50.637	1.202	**3.55***	.018
Total	44	59.203			

***The required F value to be significant at 0.05 level = $F_{(2, 42)} = 3.22$**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-.88*		
$A_2 - A_3$	.96*	.98	**3.55***
$A_1 - A_3$	-.07		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

$F_{(2, 42)} = 3.22$ is significant at the 0.05 level

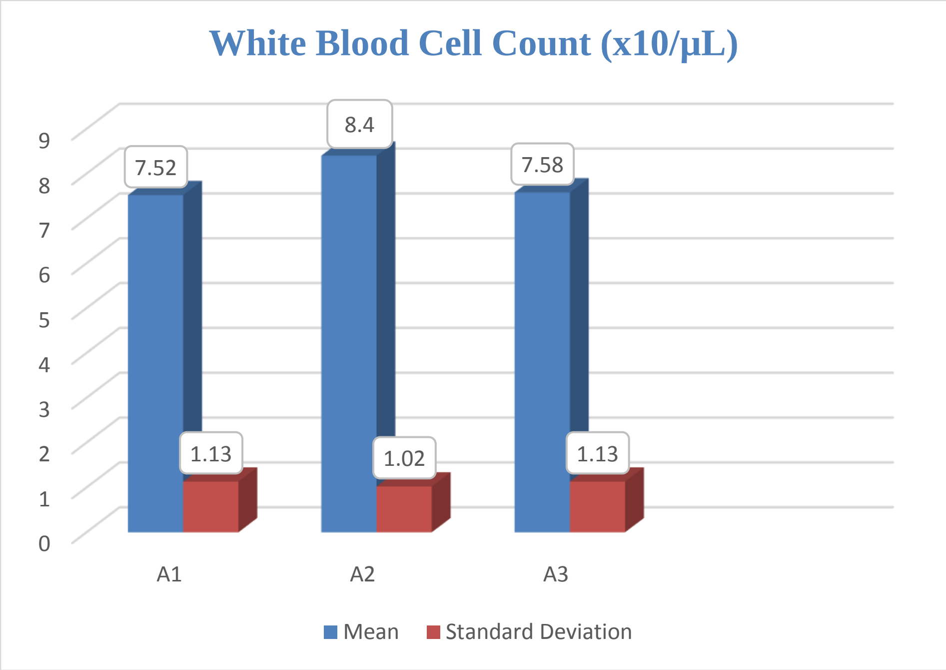
In **Table no. 19** showed that the mean and standard deviation values at the three training states for white blood cell count of experimental group were **7.52 ± 1.12, 8.40**

± 1.02 and **7.58 ± 1 .13** respectively. The results are also presented in graphical form in **Fig no. 17**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **19** shows that the F- value of **3.55** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

The above table reveals no significant difference only between A2 and A3 and other two mean differences (A1 and A2 and A1 and A3) were significant.

Fig no- 17 Graphical representation among the means of three training states of White Blood Cell Count (x10^3/µL) of young swimmers



Discussion on White Blood Cell

The result of the study indicated that white blood cell counts increased after twelve weeks and decreased end of twenty-four weeks, this variation was statistically significant. Similar variations in white blood cell count were observed in male athletes during their preparation to competition period (Bachero-Mena, et al., 2017; Bekris, et al., 2015). Some research reports consistent with present results, during their long-term swimming training (Manna & Khanna, 2013; Li, et al., 2012; Rushall & Busch, 1985; Santhiago, et al., 2009). White blood cells are components in human immune system that actively seek out and fight various forms of infection. During physical exercise these cells increase their numbers and circulate more quickly through the body. The effect may also result from the presence of other parts of body immune system, called antibodies, which also accelerate their activity level during physical exercise. During physical exercise, increased activity by the white blood cells can improve body ability to fight off virus and bacterial infection. Researchers have assessed the effect that different sports had on an athlete's white blood cell count. Neutrophinia, or a low neutrophil count, was most commonly observed in endurance athletes. Theories suggested by researchers include: (a) Faster cell death, (b) Decreased production of neutrophils in the bone marrow, (c) The cells migrating out of the bloodstream and into the tissues at an increased rate, (d) The increase in plasma volume seen in endurance athletes. Overall, these findings indicate that the low white blood cell count in athletes may be a normal adaptive response to high intense activities (Horn, Pyne, Hopkins, & Barnes, 2010).

Some researchers are observed significantly increased in white blood cell following training program (Kostrzewa-Nowak, et al., 2015; Bezci & Kaya, 2010; Karakoc, Duzova, & Emre, 2005; Vogelaere, 1988).

Some other researchers are observed significantly decreased in white blood cell following training program (Turgay, et al., 2019; Pouramir, Haghshenas, & Sorkhi, 2004; Boyadjiev & Taralov, 2000)

As the body defenders against infections, white blood cells (WBC) also contribute indirectly to performance by keeping athletes well enough (infection free) to maintain their training programme (Horn, Pyne, Hopkins, & Barnes, 2010).

From the findings, of the present study and reviewing the research reports relating to white blood cell it may be concluded that white blood cell may be altered due to influence of exercise training, depending on the nature, intensity and duration of the training.

4.4.1.c. Platelets count (x10^3/µL)

Platelets also known as thrombocytes, are component of blood whose function is to react to bleeding from blood vessel injury by clumping, thereby initiating a blood clot.

Table: 20 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Platelets count ($x10^3/\mu L$) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	1.88	.41	.10	1.13	2.70
A_2	15	2.32	.45	.11	1.65	3.50
A_3	15	2.02	.44	.11	1.55	3.22

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	1.532	.766	**4.09***	.023
Within Groups	42	7.865	.187		
Total	44	9.398			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-.44*	.31	**4.09***
$A_2 - A_3$	.30		
$A_1 - A_3$	-.14		

A_1 = pre-training state; A_2 =12^th^ weeks of training state; A_3 = 24^th^ week of training state

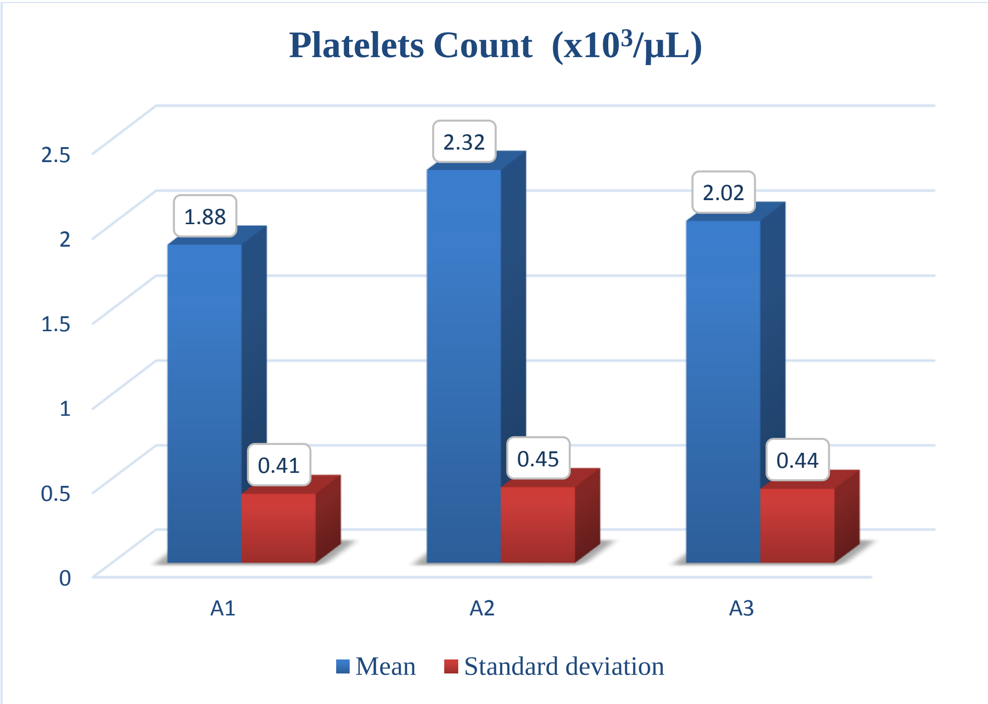
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 20** showed that the mean and standard deviation values at the three training states for platelets count of experimental group were **1.88 ± .41, 2.32 ±.45** and **2.02 ± .44** respectively. The results are also presented in graphical form in **Fig no. 18**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **20** shows that the F- value of **4.09** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

The above table reveals significant difference only between A1 and A2 and other two mean differences (A1 and A3 and A2 and A3) were not significant.

Fig no- 18 Graphical representation among the means of three training states of Platelets count (x10^3/µL) of young swimmers



Discussion on Platelets count

The result of the study indicated that platelets significantly difference during the specific training period. Regarding effect of training on platelets count change observed among the findings while, Belviranli, Kabak, & Okudan, (2017), Kostrzewa-Nowak, et al., (2015), Bezci & Kaya, (2010), Wardyn, et al., (2008), Satoshi, et al., (2005), Karakoc, Düzova, & Emre, (2005) have observed that significantly increased in platelets different sports training program.

Some researchers reported their research reports that significantly decreased in platelets before and after specific training program (Samavatisharif, Ranjbar, & Sazvar, 2013; Varamenti, et al., 2013; Savucu, 2012).

Platelets function is directly and indirectly affected by physical activity. In this regard, several mechanisms and cell or tissue types are supposed to contribute to the observed effects. Acute exercise results in increased levels of catecholamines as well as increased shear and oxidative stress, Notably, while short-term exercise training enhances production and bioavailable of NO, long-term adaptions taking place in specific vascular regions induce structural change to the vessel resulting in an increase in lumen diameter, while normalizing endothelial NO production.

From the findings, of the present study and reviewing the research reports relating to platelets it may be concluded that platelets altered due to influence of exercise training, depending on the nature of the training regimen.

4.4.1.d. Hemoglobin concentration (g/dL)

Hemoglobin, is the iron containing oxygen transport metalloprotein in red blood cells of almost all vertebrates as well as some invertebrates. Hemoglobin in blood carries oxygen from the lungs or grill to the rest of the body. There it releases the oxygen to permit aerobic respiration to provide energy to power the functions of the organism in the process called metabolism. A healthy individual has 12 to 20 grams of hemoglobin in every 100 ml of blood.

Table: 21 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Hemoglobin concentration (g/dL) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	12.03	1.07	.27	10.40	14.90
A_2	15	12.96	.70	.18	11.70	14.30
A_3	15	12.28	.71	.18	11.10	13.80

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	6.881	3.441	**4.76***	.014
Within Groups	42	32.347	.723		
Total	44	37.228			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	-.92*	.62	**4.76***
A_2 - A_3	.67*		
A_1- A_3	-.25		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

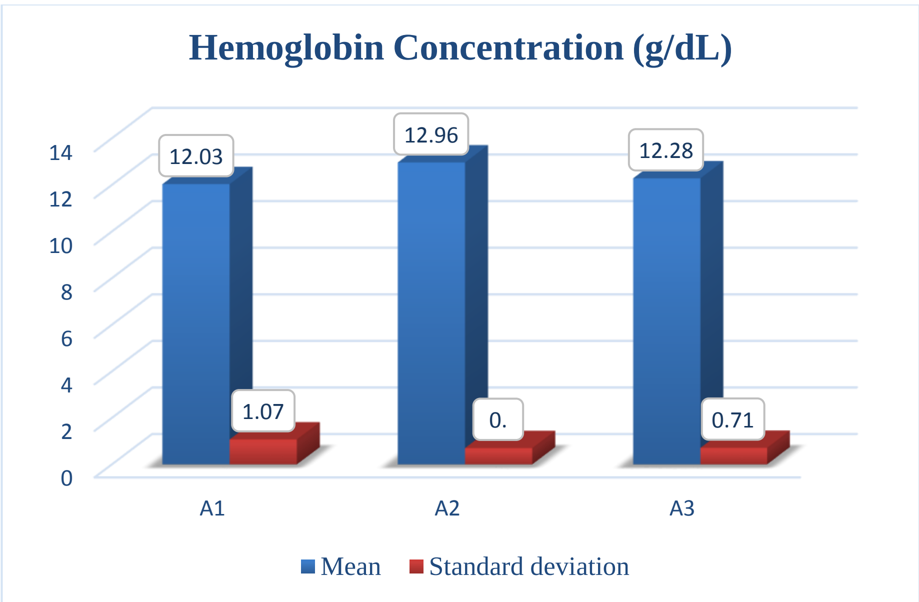
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 21** showed that the mean and standard deviation values at the three training states for hemoglobin concentration of experimental group were **12.03 ± 1.07, 12.96 ± .70** and **12.28 ± .71** respectively. The results are also presented in graphical form in **Fig no. 19**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **21** shows that the calculate F- value of **4.76** is statistically significant variations as, it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training states, the Post- Hoc test was applied.

The above table reveals no significant difference only between A1 and A3 and other two mean differences (A1 and A2 and A2 and A3) were significant.

Fig no- 19 Graphical representation among the means of three training states of Hemoglobin concentration (g/dL) of young swimmers



Discussion on Hemoglobin Concentration

The result of the study indicated that hemoglobin concentration increased after twelve weeks and decreased end of twenty-four weeks, this variation was statistically significant. Similar variations in hemoglobin concentration were observed in male athletes during their preparation to competition period (Bachero-Mena, et al., 2017; Bekris, et al., 2015). Some research reports consistent with present results, during their long-term swimming training (Manna & Khanna, 2013; Li, et al., 2012; Rushall & Busch, 1985; Santhiago, et al., 2009).

Regarding effect of training on hemoglobin concentration change observed among the researchers while, Bijeh, et al., (2013), Erdemir, Okmen, & Savucu, (2013), Bezci & Kaya, (2010), Varamenti, et al., (2013), Ibis, Hazar, & Demirci, (2010), Wardyn , et al., (2008) has observed that significantly increased in hemoglobin concentration of specific training.

A number of research reports exhibited that significantly decreased in hemoglobin concentration following training (Turgay, et al., 2019; Cicek, 2018; Belviranli, Kabak, & Okudan, 2017; Kostrzewa-Nowak, et al., 2015; Manna, Khanna, & Dhara, 2012; Kilic-Toprak, et al., 2012; Karakoc, Düzova, & Emre, 2005)

The absolute hemoglobin concentration is increased mainly because of exercise induced erythrocytosis stimulation; however, this procedure is not evidenced because of the far greater rise in plasma volume (Schumacher, et al., 2002). It has been shown that there is a tendency of hemoglobin to decrease in during a resistance training period. This phenomenon called sports anemia. This is due to the increased erythrocyte membrane instability caused by elevated levels of circulating catecholamines, osmotic stress from venous acidosis, and the increased movement of erythrocytes. Hemoglobin decreased significantly during the intensive training period; it is indicating a strong possibility enhanced hemolysis (Silva, et al., 2008).

An acute reduction of blood hemoglobin concentration [Hb, even when the circulating blood volume is maintained, results in lower VO_2 max and endurance performance, due to the reduction of the oxygen carrying capacity of blood. Conversely, an increase of [Hb] is associated with enhanced VO_2 max and endurance capacity, that is also proportional to the increase in the oxygen carrying capacity of blood. During submaximal exercise, there is a tight coupling between O_2 demand and O_2 delivery, such that if Hb is acutely decreased muscle blood flow is increased proportionally and vice versa. During maximal exercise with either a small or a large muscle mass, neither peak cardiac output nor peak leg blood flow are affected by reduced Hb. An acute increase of Hb has no effect on maximal exercise capacity or VO_2 max exercise in acute hypoxia (Calbet, et al., 2006).

From the findings, of the present analysis and reviewing the research reports relating to hemoglobin concentration, it concluded that hemoglobin concentration altered due to influence of exercise training, depending on the nature of the training regimen.

4.4.1.e. Hematocrit (%)

The hematocrit is the proportion, by volume, of the blood that consists of red blood cells. The hematocrit (hct) is expressed as a percentage (%).

Table: 22 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Hematocrit (%) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	40.35	2.62	.67	37.30	45.80
A_2	15	43.65	2.67	.69	40.30	49.70
A_3	15	41.40	3.42	.88	34.50	47.60

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	85.315	42.658		
Within Groups	42	361.335	8.603	**4.95***	.012
Total	44	446.650			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	-3.30*	2.15	**4.95***
$A_2 - A_3$	2.25*		
$A_1 - A_3$	-1.04		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

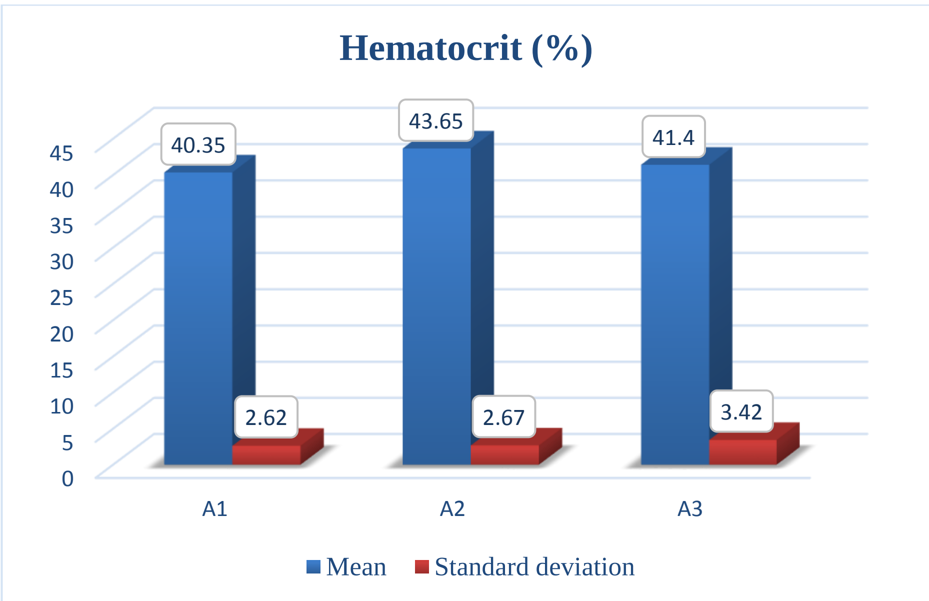
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 22** showed that the mean and standard deviation values at the three training states for hematocrit of experimental group were **44.35 ± 2.62, 43.65 ± 2.67** and **41.40 ± 3.42** respectively. The results are also presented in graphical form in **Fig no. 20**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **22** shows that the F- value of **4.95** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training states, the Post- Hoc test was applied.

The above table reveals no significant difference only between A1 and A3 and other two mean differences (A1 and A2 and A2 and A3) were significant.

Fig no- 20 Graphical representation among the means of three training states of Hematocrit (%) of young swimmers



Discussion on Hematocrit

The result of the study indicated that hematocrit increased after twelve weeks and decreased end of twenty-four weeks, this variation was statistically significant. Similar variations in hematocrit were observed in male athletes during their preparation to competition period (Bachero-Mena, et al., 2017; Bekris, et al., 2015). Some research reports consistent with present results, during their long-term swimming training (Manna & Khanna, 2013; Li, et al., 2012; Rushall & Busch, 1985; Santhiago, et al., 2009).

Regarding effect of training on hematocrit change observed among the researchers while, Belviranli, Kabak, & Okudan, (2017), Bijeh, et al., (2013), Erdemir, Okmen, & Savucu, (2013), Varamenti, et al., (2013), Ibis, Hazar, & Demirci, (2010) have found significantly increased in hematocrit following strenuous physical training program.

Some researchers have reported, Cicek, (2018), Kostrzewa-Nowak, et al., (2015), Kilic-Toprak, et al., (2012), (Moosavizademonir, (2011), Karakoc, Duzova, & Emre, (2005), Pouramir, Haghshenas, & Sorkhi, (2004), Boyadjiev & Taralov, (2000), Nuviala, et al., (1992) have found significantly decreased in hematocrit following strenuous physical training program.

Trained athletes, particularly in endurance sports, have a decreased hematocrit, which is sometimes called ‘sports anemia’. This is not anemia in a clinical sense, because athletes have in fact an increased total mass of red blood cells and hemoglobin in circulation relative to sedentary individuals. The slight decrease in hematocrit by training is brought about by an increased plasma volume. The mechanism that increases total red blood cell mass by training are not understand fully. Despite stimulated erythropoiesis, exercise can decrease the red blood cell mass by intravascular hemolysis mainly of senescent red blood cells, which is caused by mechanical rupture when red blood cells pass through capillaries in contracting muscles, and by compression of red blood cell.

From the findings, of the present study and reviewing the research reports relating to hematocrit it may be concluded that hematocrit may be altered due to influence of exercise training, depending on the nature of the training regimen.

4.4.2. Blood Lactic Acid

Lactic acid or lactate is a final chemical by-product of muscular glycolysis and used for biochemical measurement of physical exercise, both aerobic and anaerobic. Estimation of level of blood lactate expresses the metabolic adaption to effort and allow us to measure the metabolic economy before and during exercise. Level of blood lactic acid may be used as an index of the harmony of cardiorespiratory coordination to exercise. Blood lactic acid also indicates the anaerobic capacity of an individual and in this research by measuring blood lactic acid, an endeavour has been made to evaluate the metabolic adaption due to training. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

4.4.2.a. Before Onset of Exercise (Mmol/L)

Table: 23 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Before Onset of Exercise (Mmol/L) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	1.98	.45	.11	1.20	2.90
A_2	15	1.75	.24	.06	1.40	2.20
A_3	15	1.67	.21	.05	1.20	2.10

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	.795	.398	**3.79***	0.03
Within Groups	42	4.404	.105		
Total	44	5.199			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	.22	0.23	**3.79***
A_2 - A_3	.08		
A_1 - A_3	.31*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

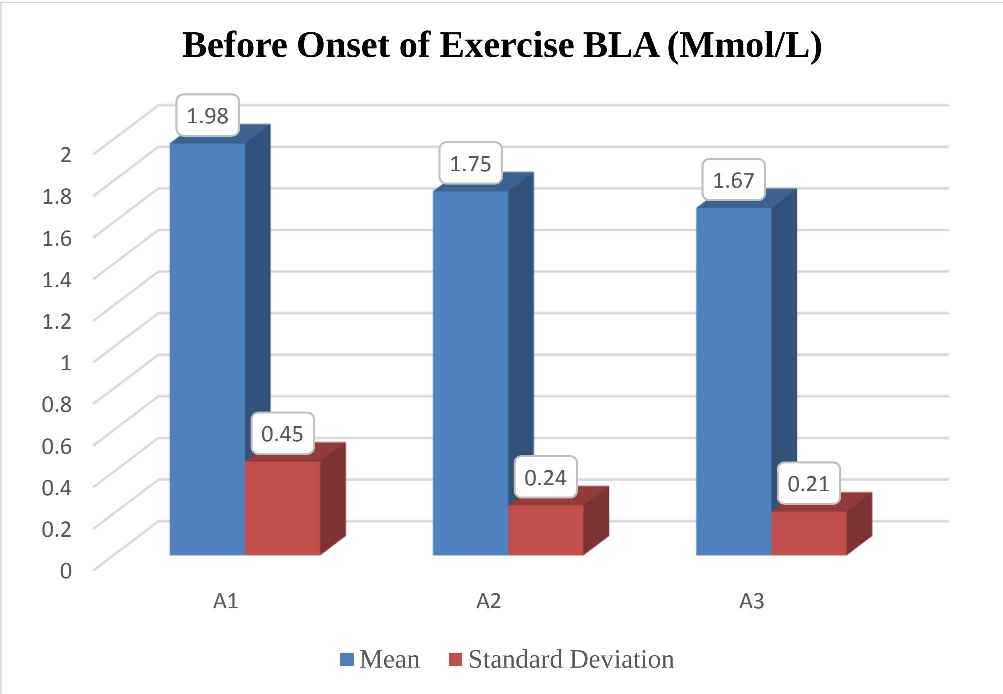
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 23** showed that the mean and standard deviation values at the three training states for before onset of exercise group were **1.98** ± **.45, 1.75** ± **.24** and **1.67** ± **.21** respectively. The results are also presented in graphical form in **Fig no. 21**

The application of analysis of variance (one-way ANOVA) in **Table no. 23** shows that the F- value of **3.79** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post-Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD .31 was higher than CD at 0.05, 0.23. other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 21 Graphical representation among the means of three training states of Before Onset of Exercise (Mmol/L) of young swimmers



4.4.2.b. BLA end of 75% Workload (1st Swim)

Table: 24 Descriptive statistics; ANOVA among the means of three training states and L.S.D of BLA end of 75% Workload (Mmol/L) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	3.61	.67	.17	2.00	4.30
A_2	15	3.35	.37	.09	2.60	3.70
A_3	15	3.06	.61	.15	2.10	4.10

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	2.299	1.150		
Within Groups	42	13.571	.323	**3.56***	0.03
Total	44	15.870			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	.26		
$A_2 - A_3$	.29	0.41	**3.56***
$A_1 - A_3$	.55*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

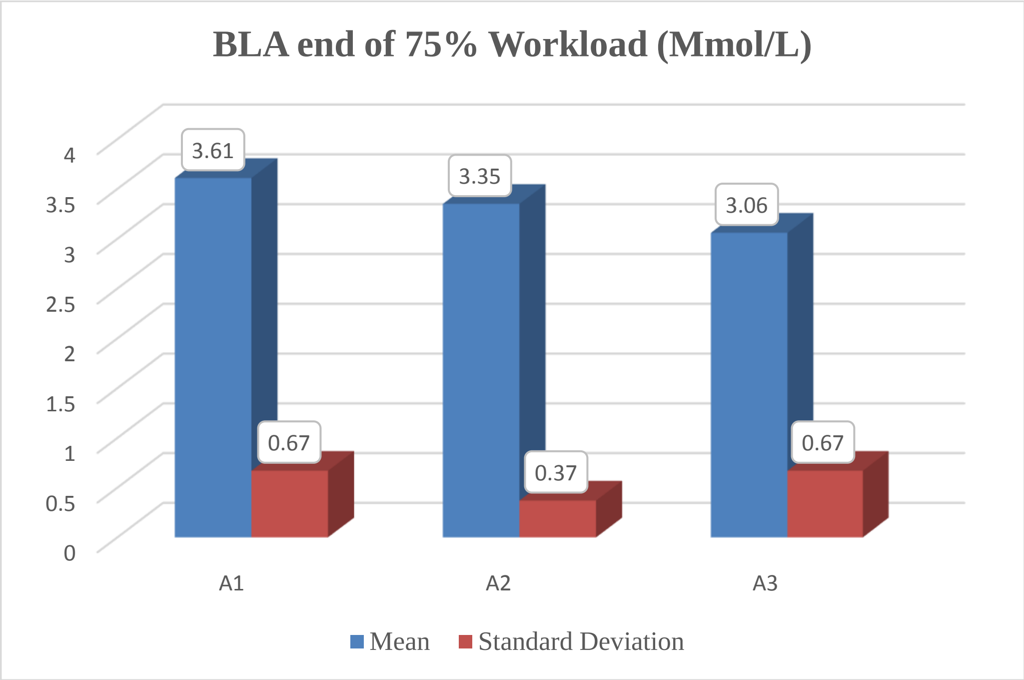
In **Table no. 24** showed that the mean and standard deviation values at the three training states for BLA end of 75% Workload experimental group were **3.61 ± .67, 3.35 ± .37** and **3.06 ± .61** respectively. The results are also presented in graphical form in **Fig no. 22**

The application of analysis of variance (one-way ANOVA) in **Table no**. **24** shows that the F- value of **3.56** is statistically significant as it is greater than table value of $F_{.05}$

(2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD .55 was higher than CD at 0.05, 0.41. other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 22 Graphical representation among the means of three training states of BLA end of 75% Workload (Mmol/L) of young swimmers



4.4.2.c. BLA end of 85% Workload (2nd Swim)

Table: 25 Descriptive statistics; ANOVA among the means of three training states and L.S.D of BLA end of 85% Workload (Mmol/L) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	5.32	1.22	.31	2.60	6.80
A_2	15	4.90	.70	.18	3.60	5.80
A_3	15	4.31	.88	.22	2.60	5.70

One-way ANOVA:

Training state	Df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	7.670	3.835	**4.16***	0.02
Within Groups	42	38.701	.921		
Total	44	46.371			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	.42	0.70	**4.16***
A_2 - A_3	.58		
A_1 - A_3	1.00*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

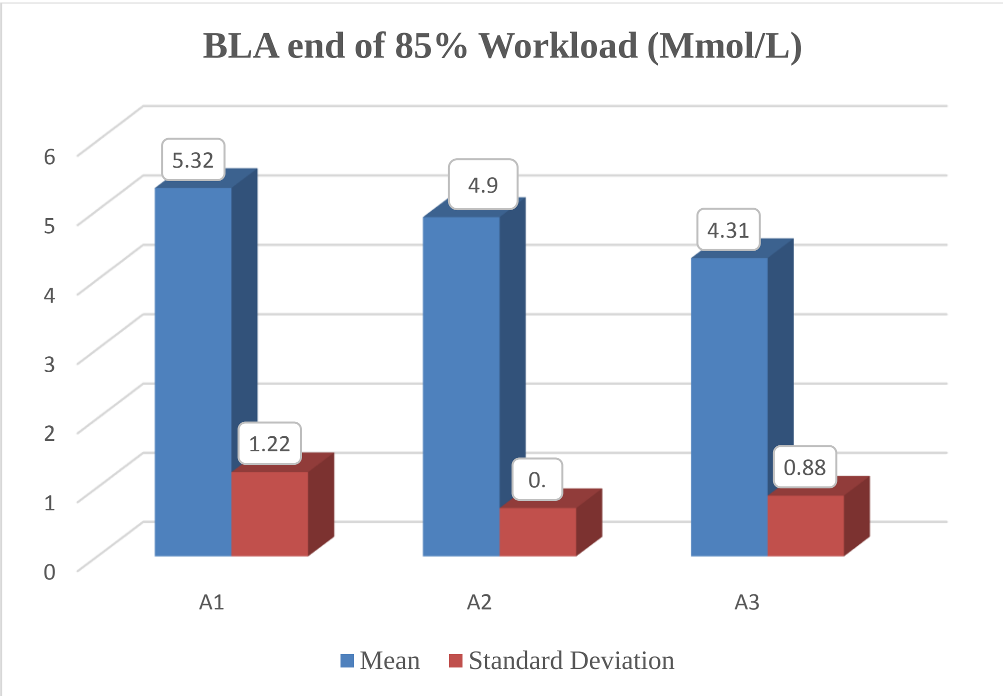
For a given work load the concentration of lactic acid (LA) in the blood increased linearly with time. In **Table no. 25** showed that the mean and standard deviation values at the three training states for BLA end of 85% workload experimental group were **5.32 ± 1.22, 4.90 ± .70** and **4.31 ± .88** respectively. The results are also presented in graphical form in **Fig no. 23**

The application of analysis of variance (one-way ANOVA) in **Table no**. **25** shows that the F- value of **4.16** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD 1.00 was higher than CD at 0.05, 0.70. other two sets between A1 & A2 and between A2 & A3 were not significant.

In the study conducted by Agaoglu, et al., (2010) seventeen male adolescent swimmers trained under different work load for maximal loading, the anaerobic threshold was 4 Mmol/L in this study. The threshold of 4 millimoles of lactic acid indicates that the anaerobic and aerobic systems contributed equally to the resynthesis of ATP (Bonifazi, Martelli, Marugo,, Sardella, & Carli, 1993). In the present study accepted an anaerobic threshold level of 4 Mmol/L. Thus, at the workloads under anaerobic threshold decrease contribution of anaerobic energy (75% and 85% swimming workloads), over anaerobic threshold increases contribution of anaerobic energy (90%, 95% and 100% swimming workloads). These studies have shown a decrease in the accumulation of LA during given sub-maximal exercise after training also means that the anaerobic threshold has increased (Wakayoshi, et al., 1993; Mayes, Hardman, & Williams, 1987; Hurley, et al., 1984; Fox, 1973).

Fig no- 23 Graphical representation among the means of three training states of BLA end of 85% Workload (Mmol/L) of young swimmers



4.4.2.d. BLA end of 90% Workload (3rd Swim)

Table: 26 Descriptive statistics; ANOVA among the means of three training states and L.S.D of BLA end of 90% Workload (Mmol/L) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	7.06	.93	.24	5.60	8.40
A_2	15	6.42	.83	.21	4.60	7.70
A_3	15	6.06	.97	.25	4.60	8.50

One-way ANOVA:

Training state	Df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	7.787	3.894		
Within Groups	42	35.439	.844	**4.61***	0.01
Total	44	43.226			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	.64		
$A_2 - A_3$	.36	0.67	**4.61***
$A_1 - A_3$	1.00*		

A_1 = pre-training state; A_2 =12^th^ weeks of training state; A_3 = 24^th^ week of training state

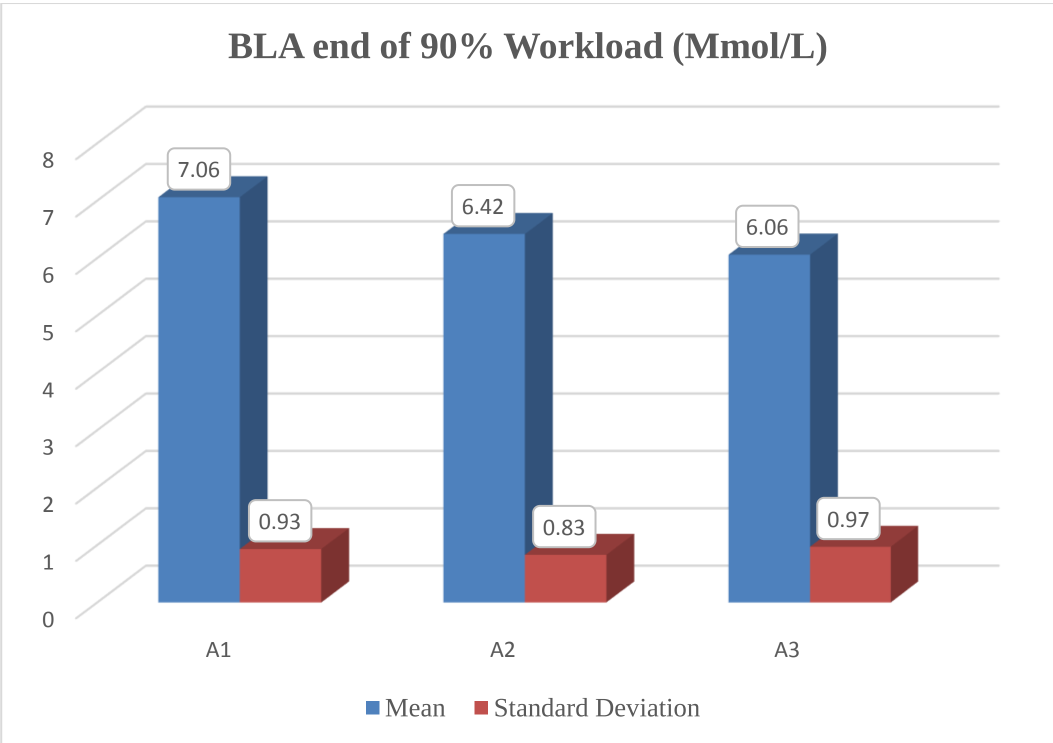
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 26** showed that the mean and standard deviation values at the three training states for BLA end of 90% workload experimental group were **7.06 ± .93, 6.42 ± .83** and **6.06 ± .97** respectively. The results are also presented in graphical form in **Fig no. 24.**

The application of analysis of variance (one-way ANOVA) in **Table no**. **26** shows that the F- value of **4.61** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD 1.00 was higher than CD at 0.05, 0.67. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 24 Graphical representation among the means of three training states of BLA end of 90% Workload (Mmol/L) of young swimmers



4.4.2.e. BLA end of 95% Workload (4th Swim)

Table: 27 Descriptive statistics; ANOVA among the means of three training states and L.S.D of BLA end of 95% Workload (Mmol/L) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	8.51	1.65	.42	5.60	10.80
A_2	15	7.77	1.14	.29	4.80	8.90
A_3	15	7.30	.82	.21	5.30	8.60

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	11.219	5.610	**3.57***	0.03
Within Groups	42	66.087	1.573		
Total	44	77.306			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	.74	0.92	**3.57***
A_2 - A_3	.47		
A_1 - A_3	1.21*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

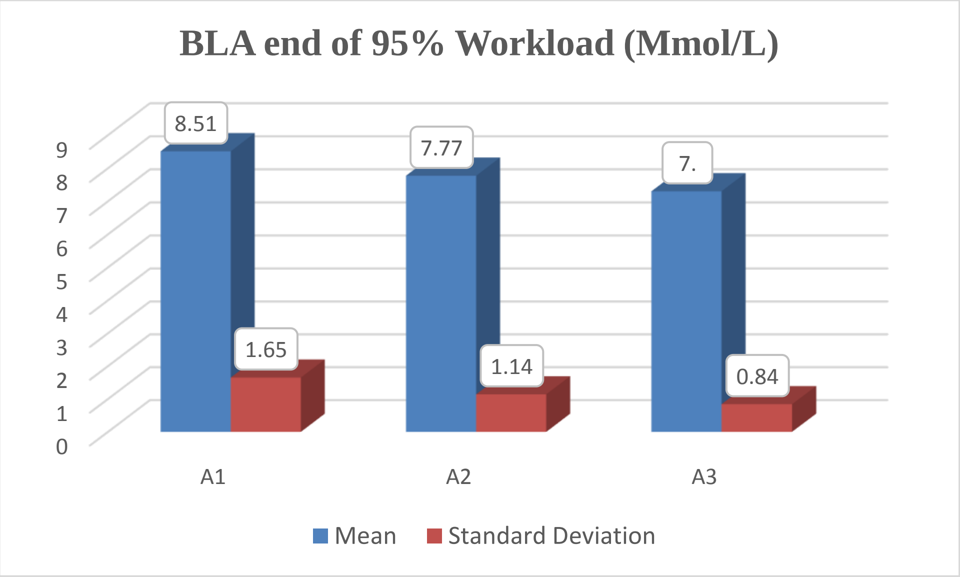
In **Table no. 27** showed that the mean and standard deviation values at the three training states for BLA end of 95% workload experimental group were **8.51 ± 1.65, 7.77 ± 1.14** and **7.30 ± .82** respectively. The results are also presented in graphical form in **Fig no. 25.**

The application of analysis of variance (one-way ANOVA) in **Table no**. **27** shows that the F- value of **3.57** is statistically significant as it is greater than table value of $F_{.05}$

(2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD 1.21 was higher than CD at 0.05, 0.92. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 25 Graphical representation among the means of three training states of BLA end of 95% Workload (Mmol/L) of young swimmers



4.4.2.f. BLA end of 100% Workload (5th Swim)

Table: 28 Descriptive statistics; ANOVA among the means of three training states and L.S.D of BLA end of 100% Workload (Mmol/L) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	10.74	1.88	.48	8.10	12.90
A_2	15	10.12	1.52	.39	8.20	12.80
A_3	15	9.35	.85	.22	8.00	10.80

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	14.609	7.312	**3.32***	0.04
Within Groups	42	92.499	2.202		
Total	44	107.108			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	.62	.94	**3.32***
$A_2 - A_3$	.76		
$A_1 - A_3$	1.39*		

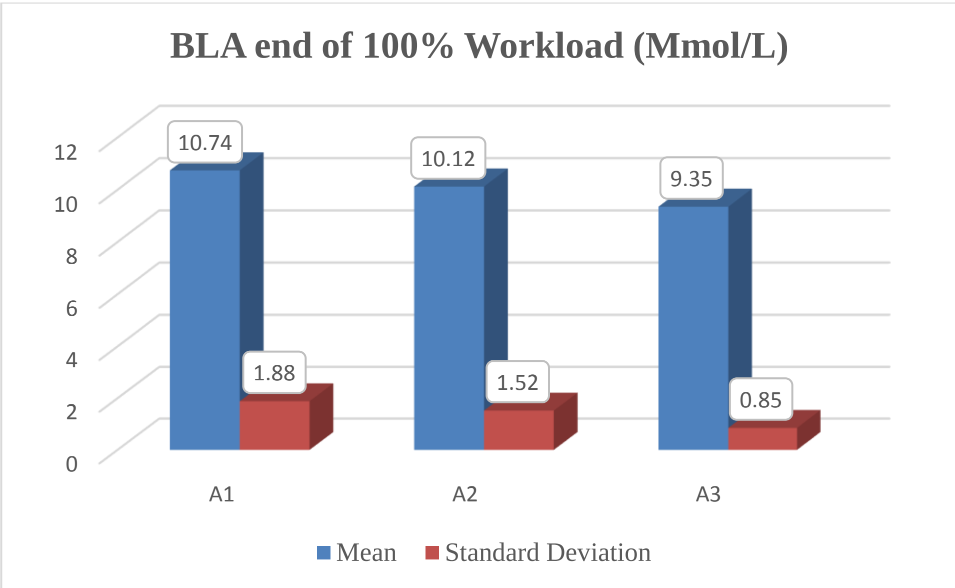
A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

Blood lactic acid (BLA) is increased in direct proportion with the duration and total work output of all-out exercise. In the present study 800m free-style swimming with the varying work load (from 75% to 100% intensity). In **Table no. 28** showed that the mean and standard deviation values at the three training states for BLA end of 100% workload subjects were **10.74 ± 1.88, 10.12 ± 1.52** and **9.35 ± .85** respectively. The results are also presented in graphical form in **Fig no. 26.** It appears from the table that in comparison to 75% to 95% exercise phase the accumulation of BLA at 100% was higher the subjects and this is true before onset of training as well as 12 and 24 wks. of training respectively. This simply because of higher work intensity of exercise. However, accumulation of BLA following maximal work out decreased considerably following training.

The application of analysis of variance (one-way ANOVA) in **Table no**. **28** shows that the F- value of **3.32** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD 1.39 was higher than CD at 0.05, 0.94. Other two sets between A1 & A2 and between A2 & A3 were not significant.

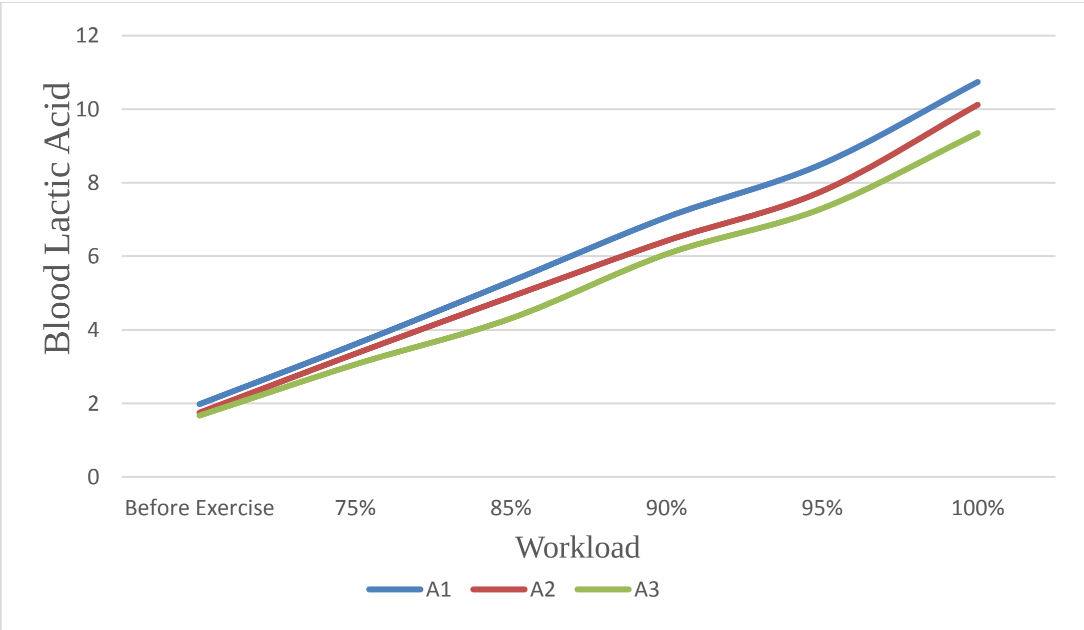
Fig no- 26 Graphical representation among the means of three training states of BLA end of 100% Workload (Mmol/L) of young swimmers



The of accumulation of BLA with changing work load is depicted in **Fig. no**. **26** The results indicated that with the gradual increment of work load, accumulation of BLA increased accordingly. The pattern was same before onset of training as well as after 12 and 24 weeks of training respectively. The classical point was that at both sub-maximal and maximal exercise intensity, at a given work load accumulation of BLA was decreased considerably. This may be evident from the mean scores of before onset of training, 75%, 85%, 90%, 95% and 100% of workload and relation to A1, A2, A3. However, the magnitude of decrement of BLA with the progrss of training was more pronounced of the subjects. It means a better cardiorespiratory adaptation have occurred due to training. The higher BLA accumulation at sub-maximal and maximal exercise at three states of training (pre, 12, 24 wks) in the subjects, may be attributed by saying that at a given work load subjects consumed a higher percentage of VO_2 max and therefore a higher BLA accumulation was evident. Fox & Mathews, (1981) have indicated that one of the most important bio-chemical changes that take place during maximal exercise following training is the ability to produce greater quantities of BLA during exhustive maximal work and this resulted from increase in the glycolytic capacity.

A study Karlsson & Saltin, (1970) have indicated that after short-termmaximal exrcise that trainined subjects always exhibited higher levels of muscle and blood lactic acid as well as grreater depletion of muscle glycogen. Critically anaiysing the verious aspects of accumulation of BLA following exercise and traoning. McArdle, Katch, & Katch, (1991) opined that 'individuals with greater pain tolerance', 'toughness', or ability to 'push' beyond the discomforts of fatiguing exercise definitely accomplish more aerobic work. The people usually generate greater levels of blood lactate and glycogen depletion; they also score higher on tests of short-term energy capacity. In the present study subjects showed some what better performance in some of test items and therefore, it may be concluded that training influence were more pronounced in them. Moreever, specific training program planned for the subjects perhaps resulted a better cardiorespiratory and metabolic adaptation and there by manifested improved performance capacity in a better way. Margaria, Cerretelli, & Mangili, (1964) have show that maxumum aerobic power of the subjects may be determined from the level of BLA accumulation following exercise and opined that when VO_2 max measurement is not possible, maximum aerobic power may be determined from the level of BLA.

Fig no- 27 Graphical representation among the means of three training states of BLA against different workload (Mmol/L) of young swimmers



Discussion on Blood Lactic Acid

The results of the present study indicated that blood lactic acid (rest & 75%, 85%, 90%, 95%, 100% workload) significantly decreased during the specific training period. Training causes a decrease in the accumulation of lactic acid during a given submaximal exercise (Fox & Mathews, 1981). Lactic acid (LA) beginning to accumulate and rise in an exponential fashion at about 55% of untrained subject's maximal capacity for aerobic metabolism. The explatation for the increse in lactic acid is based on the assumption of a relative tissue hypoxia in heavy exercise. It is argued that under these condition of O_2 deficiency the energy requiredment is partially made by a predominance of anaerobic glycolysis as the release of hydrozen begins to exceed its oxidation down the respiratory chain consequenty, excess hydrogens are passed to pyruvic acid and lactic acid accumulates. This increase in lactic acid becomes greater as exercise becomes more intense (McArdle, Katch, & Katch, 1991).

The accumulation of lactic acid the subjects of the present study (15.21 years) would be less than adult standard value and that may me due to smaller relative muscle mass in comparision to adult and lower concentration of enzymes.

Eriksson, Gollnick, & Saltin, (1973) showed that increment of concentration of blood lactate following a vigorous sub-maximal exercise would be less in comparison to the adult and they opined that this may be either due to the better perfussion of the active muscle or a faster circulatory on trensient.

Astrand, (1960) opined that lactic acid concentration increases during and after severe exercise. The lactic acid is produced in the muscle during the actual work but there is a time lag for the diffusion from the woring muscles and redistribution within the body. He futher opined that for determination of peak lactic acid in blood, samples must be taken at interval during first 5 to 10 mins of the recovery period and it may take 60 mins or even longer time to reach the resting level.

During light exercise blood lactate level remains fairly stable even through O_2 consumption increases. If the work intensity is increases, and if the subject consume 55-65% of his maximal O_2 uptake capacity the blood lactate begins to show a systematic increases (Vescovi, Falenchuk, & Wells, 2011; Agaoglu, et al., 2010), in case of highly trained endurance athlete it is about 80%.

Training causes a decrease in the accumulation of lactic acid durining a given submaximal exercise (Rashidi, Salehian, & Vaezi, 2013; Soultanakis, Mandaloufas, & Platanou, 2012; Wakayoshi, et al., 1993; Hurley, et al., 1984). A decreased BLA accumulation during exercise following training also means also means that anaerobic threshold has increased (Pyne, Lee, & Swanwick, 2001; Stasiulis & Romutis, 2000; Spengler, et al., 1999). This is an important change, since most work, including that performed during training sessions, is to a large extent sub-maximal. The physiological mechanisms responsible for decreased accumulation of lactic acid during sub-maximal exercise following training are not entirely known, possible reasons are as follows-

(i) A greater utilization fatty acid as a metabolic fuel to fulfill the energy requirements of the exercise would result in less glycogen usage and thus small amount lactic acid produced in the muscles.

(ii) A small oxygen deficit incurred at the beginning of exercise due to rapid increase in oxygen consumption could also lead to less lactic acid accumulation (Karlsson & Saltin, 1970)

(iii) A greater use (oxidation of lactic acid produced as a metabolic fuel during exercise would also result in lowered lactic acid accumulation.

(iv) Another possible mechanism following training could be a result of biochemical changes, increased the number and size of muscle mitochondria, the steady state oxygen consumption which balanced the breakdown of ATP to ADP + Pi during exercise would be attained at lower concentration of ADP + Pi. After long-term training oxygen as well as ADP + Pi required per mitochondria would be less compared to before training. Since the level of ADP + Pi controls the rate of glycolysis, their lower levels after training would cause the rate of lactic acid production to be lower during exercise at the same workload. (Mathews & Fox , 1976).

Fox, (1973) has shown that endurance training has much lower level of BL during sub-maximal exercise than have the sprint trainees which point out that the anaerobic threshold is increased with endurance training.

Brouha, (1974) mentioned that BLA varied markedly according to the kind of test performed and to the nature of the training. He has concluded that for a practically identical cardiovascular reaction, accumulation of BLA may be different if the trained person's activity is changed. Physical training has a definite and specific action in relation to BL production during muscular work.

In a study of BLA profile of the athletes, Foster, et al., (1988), Mayes, et al., (1987) pointed out that acute muscular glycogen depletion led to change in the BLA response to exercise. They found a lower concentration in lactic acid of blood during sub-maximal exercise. They also mentioned that BLA concentration during sub-maximal and maximal exercise are the production of the interaction of numerous variables of lactate production and removal rates. Fox have shown that accumulation of less lactic acid during exercise at same work load following training means that the anaerobic threshold has been increased.

From the findings, of the present study and reviewing the research reports relating to BLA it may be concluded that exercise training may have a significant influence on BLA.

4.5. Performance Related Parameters

Sports performance is the manner in which sports participation is measured. Sports performance is a complex mixture of physiological efficiency, biomechanical function, emotional factors, and training techniques. Performance in an athletic context has a popular connotation of representing the pursuit of excellence, where an athlete measures his or her performance as a progression toward excellence. Sports performance has four distinct aspects, including neuromuscular factors, the relationship with between the nervous system and its dimensions and the musculoskeletal system; mental control and psychological factors; environment conditions; and coaching and external support for the athlete. The performance related parameters were comprised of (i) swimming performance (ii) swim velocity (iii) stroke rate (iv) stroke length and (v) stroke index evaluated in present study.

4.5.1. 100m Swimming Performance (Sec)

Performance in swimming has been related to different anthropometrical, physiological, and biomechanical parameters. specifically, maximum performance in swimming depends on the amount of metabolic energy spent in transporting the body mass of the swimmers and on the economy of locomotion over the unit of swimming distance. Amount of metabolic energy varies largely from one swimmer to another, mainly depending on the specific anthropometrical and technical characteristics of the athletes. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 29 Descriptive statistics; ANOVA among the means of three training states and L.S.D of 100m Swimming Performance (Sec) of young swimmers.

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	67.20	3.18	.82	62.00	72.00
A_2	15	66.06	3.36	.86	61.00	71.00
A_3	15	64.20	3.14	.81	59.00	69.00

One-way ANOVA:

Training state	Df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	68.844	34.422	**3.28***	0.04
Within Groups	42	439.733	10.470		
Total	44	508.578			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
$A_1 - A_2$	1.13	2.11	**3.28***
$A_2 - A_3$	1.86		
$A_1 - A_3$	3.00*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 29** showed that the mean and standard deviation values at the three training states for Swimming Performance of experimental group were **67.20 ± 3.18,**

66.06 ± 3.36 and **64.20 ± 3.14** respectively. The results are also presented in graphical form in **Fig no. 28**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **29** shows that the F- value of **3.28** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD 3.00 was higher than CD at 0.05, 2.11. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 28 Graphical representation among the means of three training states of 100m Swimming Performance (Sec) of young swimmers

Discussion on 100m Swimming Performance

The result of the study indicated that swimming performance significantly increased during the specific training period. Regarding effect of training on swimming performance change observed among the researchers while, some research reports inconsistent with present study, Grant & Kavaliauskas, (2017), Santos-Garcia, et al., (2013), Aspenes, et al., (2009), Nugent, et al., (2019) have found no significant changes in swimming performance following well-structure following training.

On the other hand, Strzala & Tyka, (2007) observed that significantly influences somatic and functional factors on freestyle swimming techniques in case of young swimmers. Strass, (1986) reported that the improved in swimming performance with the intervention group after a different specific training program. Previous findings consistent with present result (Lopes, et al., 2021; Barbosa, et al., 2019; Darchini, et al., 2019; Ferreira, et al., 2019; Gourgoulis, et al., 2019; Karpinski, et al., 2019; Patel, et al., 2019; Clemente-Suarez, et al., 2018; Morais, et al., 2016; Patil, Salian, & Yardi, 2014; Schnitzler, et al., 2014; Dingley, et al., 2015; Arroyo -Toledo, et al., 2013; Sadowski, et al., 2012; Girold, et al., 2012; Garrido, et al., 2010; Santhiago, et al., 2009; Mujika, et al., 1995; Toussaint & Vervoorn, 1990).

In present study also significantly enhanced in swimming performance. From the findings, of the present study and reviewing the research reports relating to swimming performance it may be concluded that specific training program may have a significantly enhanced of swimming performance.

4.5.2. Swim Velocity (m · s-1)

Velocity is defined as the rate of change of position of an object with respect to time. As velocity is a measure of displacement this means that it is a vector quantity i.e., it must take both magnitude and direction into account whereas speed, being a scalar quantity, just accounts for magnitude. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 30 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Swim Velocity (m · s^{-1}) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	1.49	.07	.01	1.39	1.61
A_2	15	1.51	.08	.02	1.41	1.64
A_3	15	1.56	.08	.02	1.45	1.69

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	.039	.020	**3.35***	.04
Within Groups	42	.246	.006		
Total	44	.285			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	-.02	0.05	**3.35***
A_2 - A_3	-.04		
A_1 - A_3	-.07*		

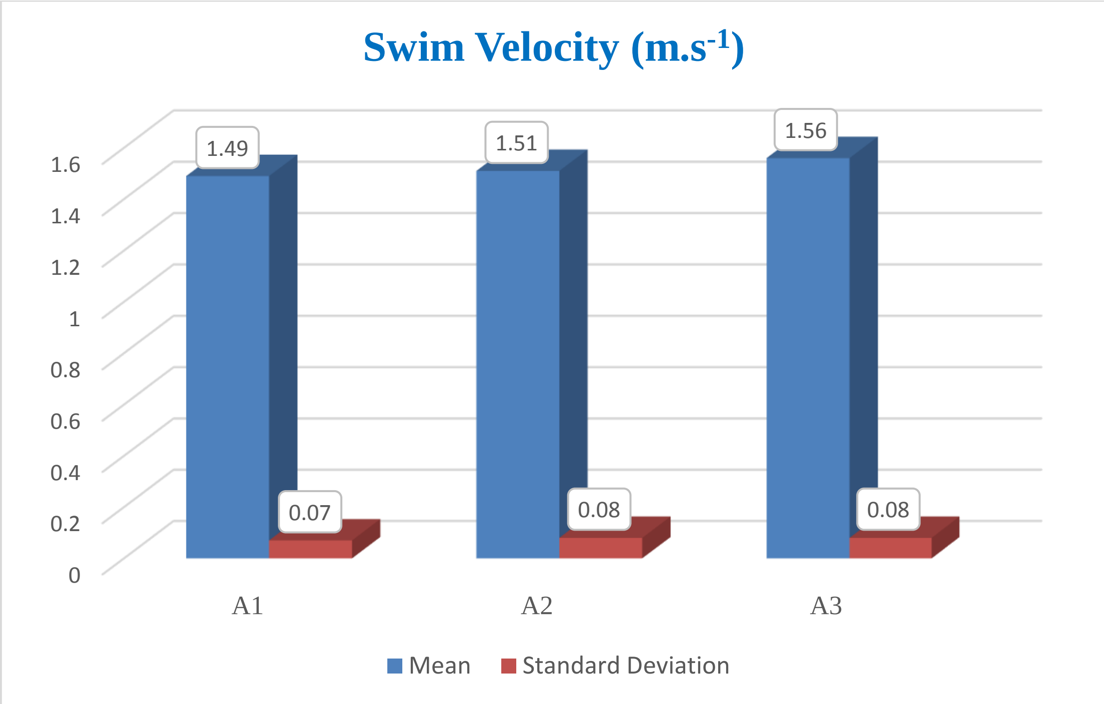
A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 30** showed that the mean and standard deviation values at the three training states for Swim Velocity of experimental group were **1.49 ± .07, 1.51 ± .08** and **1.56 ± .08** respectively. The results are also presented in graphical form in **Fig no. 29**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **30** shows that the F- value of **3.35** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD -.07 was higher than CD at 0.05, 0.05. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 29 Graphical representation among the means of three training states of Swim Velocity (m · s^{-1}) of young swimmers



Discussion on Swim Velocity

The result of the study indicated that swim velocity significantly increased during the specific training period. Regarding effect of training on swim velocity change observed among the findings while, Nugent, et al., (2019), Aspenes, et al., (2009), (Roberts, et al., (1997) have found no significant changes of swim velocity following training program.

On the other hand, a lot of research results consistent with present study, Karpinski, et al., (2019), Patil, Salian, & Yardi, (2014) have found significantly improved in swim velocity after specific training program of swimmers. Toussaint & Vervoorn, (1990) reported that significantly improved in swim velocity of specific high resistance training in water on competitive swimmers. Previous findings consistent with present result (Gourgoulis, et al., 2019; Morais, et al., 2016; Naczk, et al., 2016; Stachowicz, Milde, & Janik, 2011; Garrido, et al., 2010; Strzala & Tyka, 2007; Girold, et al., 2006; Wakayoshi, et al., 1993; Craig, et al., 1985).

From the findings, of the present study and reviewing the research reports relating to swim velocity it may be safely concluded that considerable time of training period may have a significantly enhanced of swim velocity.

4.5.3. Stroke Rate (cycle.m)

The number of strokes take per minute (counting both left and right arm). The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 31 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Stroke Rate (cycle.m) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	63.93	2.96	.76	60.00	69.00
A_2	15	62.80	3.16	.81	58.00	68.00
A_3	15	61.73	3.19	.82	57.00	67.00

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	36.311	18.156	**1.88**	0.16
Within Groups	42	406.267	9.673		
Total	44	442.578			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	1.13	2.27	**1.88**
A_2 - A_3	1.06		
A_1 - A_3	2.20		

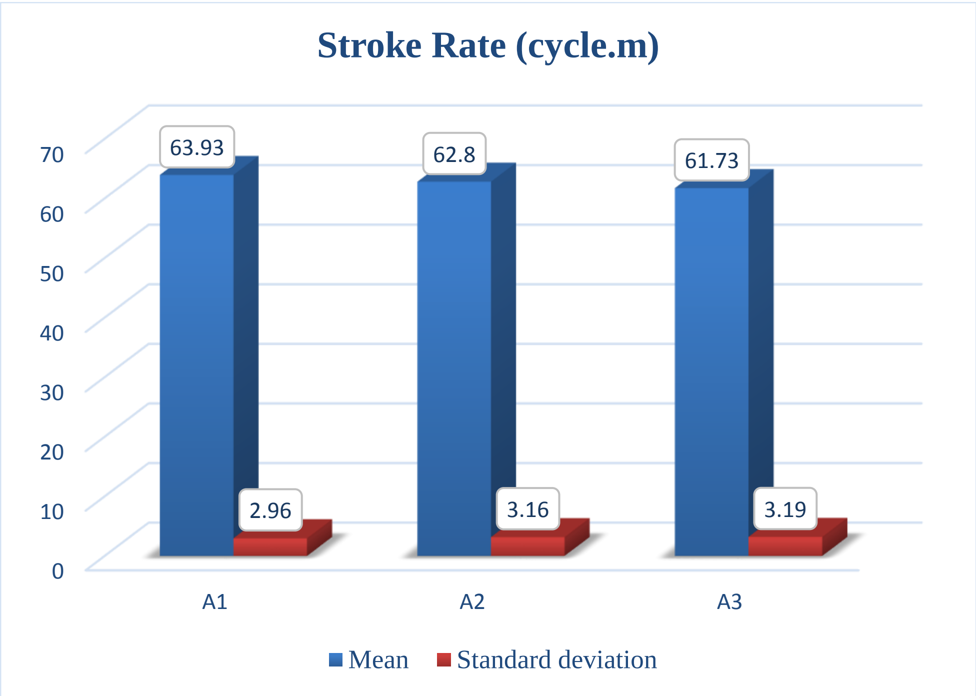
A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 31** showed that the mean and standard deviation values at the three training states for Stroke Rate of experimental group were **63.93 ± 2.96, 62.80 ± 3.16** and **61.73 ± 3.19** respectively. The results are also presented in graphical form in **Fig no. 30**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **31** shows that the F- value of **1.88** is statistically insignificant as it is lesser than table value of $F_{.05}$ (2,42) = 3.22, thus indicating insignificant differences among the three training states. To determine the significant of difference among three training state, the Post- Hoc test was applied.

Through F- value were not significant even then critical difference also calculated to find the difference the three training states of means of experimental group. The obtained critical difference (at 0.05 level) was 2.27 for experimental group and the difference between any two set of mean scores of the group was lower than required value. Probable these low mean differences were responsible for insignificant F- value.

Fig no- 30 Graphical representation among the means of three training states of Stroke Rate (cycle.m) of young swimmers



Discussion on Stroke Rate

The result of the study indicated that stroke rate slightly decreased, but statistically no significant changes during the specific training period. Regarding effect of training on stroke rate change observed among the findings while, some research reports inconsistent with present study Ferreira, et al., (2019), Patel, et al., (2019), Girold, et al., (2006) have reported that significantly increased in stroke rate following training program. On the other hands, Darchini, et al., (2019), Nugent, et al., (2019), Williams, Sinclair, & Galloway, (2001) have found significantly decreased in stroke rate after specific training period.

Many researchers report consistent with present study, Karpinski, et al., (2019), Patil, Salian, & Yardi, (2014) reported that no significant changes were obtained between baseline and at the end of specific different types of training for stroke rate. These studies have found no significant changes in stroke rate after specific training period (Barbosa, et al., 2019; Gourgoulis, et al., 2019; Schnitzler, et al., 2014; Arroyo -Toledo, et al., 2013; Sadowski, et al., 2012; Aspenes, Kjendlie, et al., 2009; Strzala & Tyka, 2007; Trappe & Pearson, 1994; Wakayoshi, et al., 1993)

From the findings, of the present study and reviewing the research reports relating to stroke rate, it may be safely concluded that technical ability was improved during the specific training period. The swimmers were able to perform at the same physiological intensity at higher velocities and with lower stoke rate.

4.5.4. Stroke Length (m.cycle)

The distance travelled (in meters or yards) from each individual stroke. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 32 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Stroke Length (m.cycle) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	1.37	.09	.02	1.24	1.59
A_2	15	1.40	.10	.02	1.26	1.61
A_3	15	1.46	.09	.02	1.34	1.67

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	.068	.034	**3.39***	.04
Within Groups	42	.421	.010		
Total	44	.489			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	-.03	0.07	**3.39***
A_2 - A_3	-.06		
A_1 - A_3	-.09*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

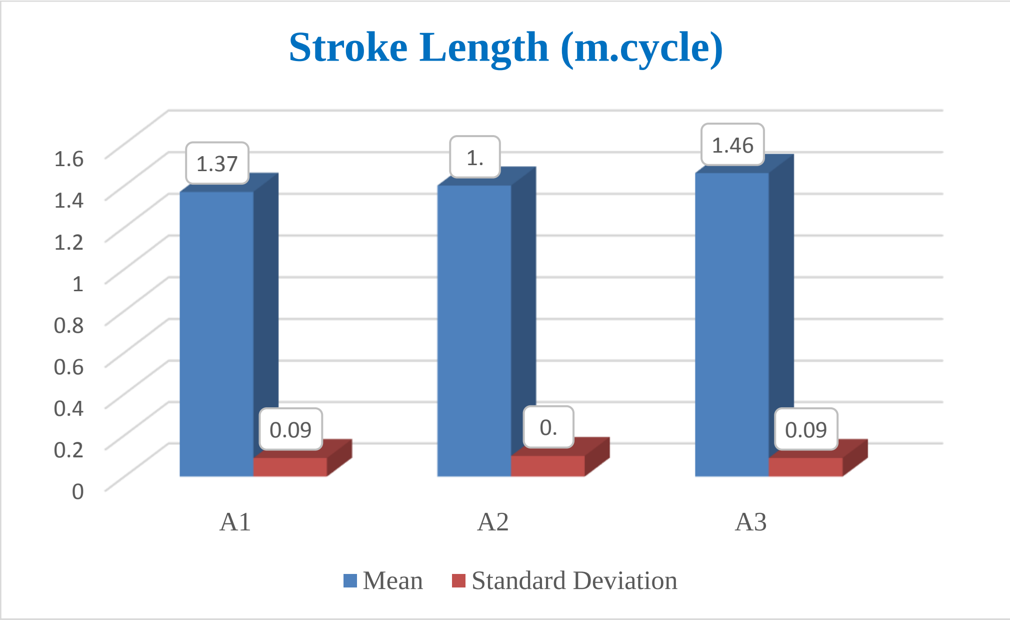
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 32** showed that the mean and standard deviation values at the three training states for Stroke Length of experimental group were **1.37 ± .09, 1.40 ± .10** and **1.46 ± .09** respectively. The results are also presented in graphical form in **Fig no. 31**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **32** shows that the F- value of **3.39** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the post-Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD -.09 was higher than CD at 0.05, 0.07. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 33 Graphical representation among the means of three training states of Stroke Length (m.cycle) of young swimmers



Discussion on Stroke length

The result of the study indicated that stroke length significantly increased during the specific training period. Regarding effect of training on stroke length change observed among the findings while, some research reports inconsistent with present study (Barbosa, et al., 2019; Darchini, et al., 2019; Gourgoulis, et al., 2019; Karpinski, et al., 2019; Sadowski, et al., 2012; Aspenes, et al., 2009; Girold, et al., 2006; Williams, Sinclair, & Galloway, 2001; Trappe & Pearson, 1994; Johns, et al., 1992).

Many researchers report consistent with present study results, Patil, Salian, & Yardi, (2014) noted a statistical progression of the stroke length result after six weeks training to strengthen the stabilizing muscles. It is worth noting in these studied the improvement in the efficiency of individual swimming elements translated into the final swimming performance. Nugent, et al., (2019), Schnitzler, et al., (2014), Arroyo - Toledo, et al., (2013), Girold, et al., (2012), Strzala & Tyka, (2007), Roberts, et al., (1997) mentioned that experimental group improved stroke length values during the training period. Wakayoshi, et al., (1993) noted that stroke length change as adaptions to six-month of aerobic swimming training, which translated into the final swimming performance.

A well-designed training may lead to substantial performance improvement, attributed to technical-biomechanical, physiological factors. Researchers noted that during the general preparation, stroke length changes may be more important, while metabolic changes may facilitate performance enhance during specific preparation and competitive period (Ferreira, et al., 2019; Toussaint & Vervoorn, 1990; Morais, et al., 2016).

From the findings, of the present study and reviewing the research reports relating to stroke length it may be safely concluded that stroke length efficiency was improved during the specific considerable time of training period.

4.5.5. Stroke Index (m^2. (s. cycle)$^{-1}$)

It is a performance index. It is an indicator of how efficiently moving through the water. The details of the test procedure are discussed in **chapter-III** and the results are presented here.

Table: 33 Descriptive statistics; ANOVA among the means of three training states and L.S.D of Stroke Index (m^2. (s. cycle)$^{-1}$) of young swimmers

Descriptive statistics:

Training state	N	Mean	Std. Deviation	Std. Error	Min.	Max.
A_1	15	2.05	.23	.06	1.73	2.56
A_2	15	2.14	.25	.06	1.78	2.64
A_3	15	2.16	.26	.06	1.92	2.78

One-way ANOVA:

Training state	df	Sum of Squares	Mean Square	F	Sig.
Between Groups	2	.418	.209	**3.29***	.05
Within Groups	42	2.663	.063		
Total	44	3.081			

***The required F value to be significant at 0.05 level = $F_{(2, 42)}$ = 3.22**

L.S.D Post Hoc test:

Intra-group	Mean Difference (MD)	Critical Difference (CD) at 0.05	F
A_1 - A_2	-.08		
A_2 - A_3	-.14	0.16	**3.29***
A_1 - A_3	-.23*		

A_1 = pre-training state; A_2 =12th weeks of training state; A_3 = 24th week of training state

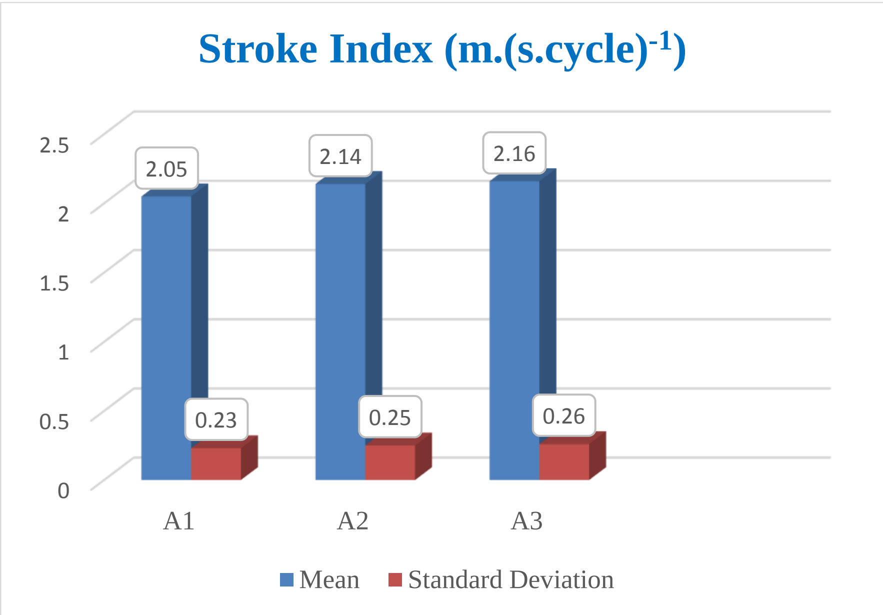
$F_{(2, 42)}$ = 3.22 is significant at the 0.05 level

In **Table no. 33** showed that the mean and standard deviation values at the three training states for Stroke Index of experimental group were **2.05 ± .23, 2.14 ± .25** and **2.28 ± .26** respectively. The results are also presented in graphical form in **Fig no. 32**.

The application of analysis of variance (one-way ANOVA) in **Table no**. **33** shows that the F- value of **3.29** is statistically significant as it is greater than table value of $F_{.05}$ (2,42) = 3.22, thus indicating significant differences among the three training states. To determine the significant of difference among three training state, the post-Hoc test was applied.

From critical difference analysis it appears that out of three paired MD between A1 & A3 was significant, since MD -.23 was higher than CD at 0.05, 0.16. Other two sets between A1 & A2 and between A2 & A3 were not significant.

Fig no- 32 Graphical representation among the means of three training states of Stroke Index (m^2. $(s.\ cycle)^{-1}$) of young swimmers



Discussion on Stroke Index

The result of the study indicated that stroke index significantly increased during the specific training period. Regarding effect of training on stroke index change observed among the findings while, some research reports consistent with present finding, Ferreira, et al., (2019) opined that stroke index, recognized practical and valid index of technical efficiency that improves with swimming training progression, showed the best correlation with 400m swimming speed. It mentioned that stroke index was a significant determinant of swimming performance changes. Nugent, et al., (2019) found that significantly improved in stroke index after low volume, high-intensity training. Researchers opined that swimming performance is determined by a number of different physiological and biomechanical parameters such as stroke index and other strike mechanics (Morais, et al., 2016). Patil, Salian, & Yardi, (2014) reported that well-design core stability or core strength exercise training enhanced the stroke index parameters, which translated into the final swimming performance. (Lopes, et al., (2021) observed that significant improved instroke index after specific dry-land strength training.

From the findings, of the present study and reviewing the research reports relating to stroke index, it may be safely concluded that stroke index efficiency was improved during the specific considerable time of training period.

4.6. ON CORRELATION STUDY

Selected Relationship among the Variables

The values obtained from different parameters were analysed so far independently but there is a certain relationship between the variables and in sports and physical education. It may so happen that it is necessary to estimate or predict an unknown from a known value. Several statistical techniques are available for representing the relationship of one parameter to another. But Pearson’s product-moment method of correlation one of the most popular which is being made in this study to find the degree of relationship between a dependent and an independent variable.

In the present study, the specific training effect has been evaluated from four-dimension, motor fitness, anthropometric measurements & body composition, physiological &biochemical and performance related variables. From the analysis of the result, it appears that as a result of participation in specific training programs different parameters in different variables have improved. For better understanding the effect of training on the various parameters and the parameters are mostly associated with the performance improvement, the coefficient of correlation study has been made.

The selected variables from five-dimensions have been considered for correlation study. The experimental group has been taken into a description in correlation study only post-test data were computed. All parameters were analyzed, but significant results were considered for the study. All significant coefficient of correlation (‘r’ value) among the variables, are presented in different tables.

4.6.1. Swimming performance with motor fitness variables

Motor fitness leads to better athletic performance, and persistent training will usually develop motor fitness. Detailed analyses of the anatomic and physiological characteristics of famous athletes show that it is possible to make fairly reliable predictions of athletic performance. Among the other factors, types of strength and power are determining the performance (Cureton, 1956). According to Ford, et al., (2011), Lloyd, et al., (2015) and (Faigenbaum, et al., 2015) muscular fitness should specifically be promoted at all stages of long-term athletics development to support motor skill acquisition, to enhance motor performance, to improve markers of health and well-being, and to reduce the risk of sustaining sports-related injuries. In fact, Geladas et al. (2005) found that leg power and handgrip strength could be used as predictors of 100-m front crawl performances. However, muscular functions, such as strength, power, and muscular endurance, are now regarded as important factors in determining performance (Ji, Yoon, Song, & Oh, 2021; Geladas, et al., 2006 and Garrido, et al., 2012).

The ‘r’ values of the correlation studies between swimming performance and motor fitness variables have been presented in the following table**.**

Table. 34 inter-coefficients of correlation? (r- values) of 100m swimming performance with the selected motor fitness variables of young swimmers at post-test.

Variables	100m swimming performance
Muscular strength	
Right hand grip muscular strength	-.642**
Left hand grip muscular strength	-.654**
Muscular strength-endurance	
Arm and shoulder strength-endurance	-.666**
Abdominal strength-endurance	-.541*
Leg explosive power	-.709**

****The required 'r' value to be significant at 0.01 level = 'r' (13) = 0.641, *The required 'r' value to be significant at 0.05 level = 'r' (13) = 0.514**

Table no. 34 shows that the motor fitness variables in relation with swimming performance (**time**) are right hand grip muscular strength (r = -.642**), left hand grip muscular strength (r = -.654**), arm and shoulder strength-endurance (r = -.666**), abdominal strength-endurance (r = -.541*), leg explosive power (-.709**) were having significant correlation. Among this right-hand grip muscular strength, left hand grip muscular strength, arm and shoulder strength-endurance, abdominal strength-endurance, leg explosive power was negative in symbol, but significant correlation with the 100m swimming performance because the performance measured in unit time.

Discussion on motor fitness variables

This study investigated the contribution of selected motor fitness variables to sprint swimming performance in young male swimmers. The main finding of this study was 100m front crawl swimming performance was significantly correlated to muscular strength, muscular strength-endurance, leg explosive strength.

Previous studies have shown a correlation between swimming performance and selected motor fitness variables, such as muscular strength (Yarar, et al., 2021; Marinho, et al., 2020), muscular strength-endurance ((Yarar, et al., 2021; Aktug, Iri & Top, 2018), leg explosive strength (Yarar, et al., 2021; Demirkan, et al., 2019; Geladas et al., 2005).

4.6.2. Swimming performance with anthropometric variables

Anthropometric characteristics also play a major role in determining one's swimming skills. A lot of works has been done when general anthropometric parameters considered as important factors affecting swimming performance. Literature reports that performance in youth swimming is highly dependent on variables related to technique and body dimensions (Morais, et al., 2021 and Bond, et al., 2015; Morais, et al., 2021). Anthropometric characteristics such as body height, arm span, chest circumference, shoulder width and body mass highly determine the swimming performance (Yarar, et al., 2021; Moura, et al., 2014; Knechtle, et al., 2010; Sonia & Nigam, 2010; Thorland, et al., 1983).

In the present study, the investigator has also attempt to find out the relationship between swimming performance and anthropometrical variables. The 'r' values of the correlation studies have been presented in the following table.

Table 35 inter-coefficient of correlation (r- values) of 100m swimming performance with the anthropometric variables of young swimmers at post-test.

Variables	100m swimming performance
Height	-.702**
Shoulder width	-.655**
Chest circumference	-.643**
Arm span	-.651**

****The required 'r' value to be significant at 0.01 level = 'r' (13) = 0.641**

Table no. 35 shows that the anthropometrical variables in relation with swimming performance are of height (r = -.702**), shoulder width (r = -.655**), chest circumference (r = -.643**), arm span (r = -.651**) were having significant correlation

Discussion on anthropometrical variables

The main finding of this study was 100m front crawl swimming performance was significantly correlated to height, shoulder width, chest circumference and arm span.

Previous studies have shown a correlation between swimming performance and selected anthropometrical variables, such as height ((Ferraz, et al., 2020; Khan & Dhingra, 2016), shoulder width (Yarar, et al., 2021; Kalayci, Gulerogu, & Eroglu, 2016), chest circumference (Yarar, et al., 2021; Sammoud, et al., 2019), arm span (Yarar, et al., 2021; Ferraz, et al., 2020; Marinho, et al., 2020; Garrido, et al., 2012; Mookherjee, et al., 1995)

4.6.3. Swimming performance with blood lactic acid (BLA)

The measurements of blood lactate concentration following competition or maximal and sub-maximal exercise have been used, at least in young subjects, to assess exercise intensity and prescribe training (Bonifazi, Sardella, & Lupo, 2000), to predict and optimize performance (Hautier , et al., 1994) and, being aware of the limitations and provided that certain precautions are taken, to quantify the contribution of the anaerobic metabolism to the effort (Smith , Norris, & Hogg, 2002; Di Prampero & Ferretti, 1999; Lacour, Bouvat, & Barthelemy, 1990).

Peaks of blood lactate concentration were observed in distances ranging from 100 to 200 m. This is even consistent with the results of studies conducted on young competitive swimmers (Avlonitou, 1996; Bonifazi, et al., 1993; Chatard, Paulin, & Lacour, 1988). In line with these findings is also the positive correlation found between blood lactate concentration and average speed achieved in the races, both in males and females (Benelli, et al., 2007 and Avlonitou, 1996). Several studies mentioned that a strong relation between blood lactate concentration and swimming performance. Whereas, Latt, et al., (2010) mentioned that blood lactate concentration was the best bioenergetical indicators of sprint swimming performance. Strzala & Tyka, (2009) found that a large contribution an anaerobic energetic process in sprints efforts lead to high post-exercise blood lactate concentration. Blood lactate values in swimmers are an indication of individual aptitudes. A direct correlation between the lactic acid concentration in capillary blood and the workload has been reported for exercise which involves aerobic as well as anaerobic metabolism (Benelli, et al., 2007; Olbrecht, et al., 1985; Jurimae, et al., 2007).

In the present study, the investigator has also attempt to find out the relationship between swimming performance and blood lactic acid (BLA). The ‘r’ values of the correlation studies between swimming performance and blood lactic acid (BLA) have been presented in Table no. 36.

Table. 36 inter-coefficients of correlation (r- values) of 100m swimming performance with the blood lactic acid (BLA) of young swimmers at post-test.

Variables	100m swimming performance
BLA end of 85% workload	-. 568*
BLA end of 90% workload	-.528*
BLA end of 95% workload	-.546*
BLA end of 100% workload	-0.588*

***The required 'r' value to be significant at 0.05 level = 'r' (13) = 0.514**

Table no. 36 shows that the blood lactic acid (BLA) in relation with swimming performance are BLA end of 85% workload (r = -.568*), BLA end of 90% workload (r = -.528*), BLA end of 95% workload (r = -0.586*), BLA end of 100% workload (r = -.598*), were having significant correlation.

Discussion on blood lactic acid

This study investigated the contribution of blood lactic acid to sprint swimming performance in young male swimmers.

Previous studies have also shown a correlation between swimming performance and blood lactic acid (Latt, et al., 2010; Benelli, et al., 2007; Bonifazi, Sardella, & Lupo, 2000; Di Prampero & Ferretti, 1999; Avlonitou, 1996), (Bonifazi, et al., 1993; Lacour, Bouvat, & Barthelemy, 1990; Olbrecht, Madsen, Mader, & Liesen, 1985; Sawka, et al., 1979).

4.6.4. Swimming performance with performance related variables

The understanding of the behaviour of stroke mechanics and its relationship to swimming velocity is one of the major points of interest in biomechanical research in swimming (Kjendlie, et al., 2006; Toussaint, et al., 2006; Keskinen & Komi, 1993; Silva, et al., 2012; Tanaka, et al., 1993). Increases or decreases in swimming velocity are due to a combined increase or decrease in stroke rate and stroke length (Toussaint, et al., 2006; Keskinen & Komi, 1993). Latt, et al., (2010) demonstrated that the improvement in velocity over a season was due to improvements in stroke length. Improvements in performance were observed with an increase in stroke length, and therefore an increase in velocity (Latt, et al., 2010). A decrease in velocity has been shown to be directly associated with a decrease in stroke length, (Fernandes, et al., 2006; Craig, et al., 1985).

Roberts, et al., (1997) and Aspenes, et al., (2009) found a decrease in stroke rate, along with a significant increase in stroke length. This suggests that by increasing stroke length there may be a decrease in stroke rate, and by increasing stroke rate there may be a decrease in stroke length. Therefore, an individualized combination of stroke rate and stroke length needs to be established to ensure optimal performance. Stroke length can therefore be shown to be an important factor in freestyle swimming (Costill, et al., Energy expenditure during front crawl swimming: predicting success in middle-distance events, 1985). Girold, et al., (2012) and Strass, (1986) found an increase in stroke length, and this transferred to an increase in swimming performance.

An investigation showed that biomechanical parameters (SI and SL) are close correlates of 100-m swimming performance, and have shown that SI is strongly related to swimming performance in adolescent swimmers also in longer distances (Jurimae, et al., 2007; Latt, et al., 2010), as well as a good predictor of overall competitive performance (Knechtle, et al., 2010; Saavedra, et al., 2010). High stroke index (SI) values are strongly associated with low cost of energy (Costill, et al., 1985). In this sense, and following the referred authors, SI can also be used as an overall estimation of swimming efficiency.

In the present study, the investigator has also attempt to find out the relationship between swimming performance and performance related variables. The ‘r’ values of the correlation studies between swimming performance and performance related variables have been presented in the following table.

Table no. 37 inter-coefficient of correlation (r- values) of 100m swimming performance with the performance related variables of young swimmers at post-test.

Variables	100m swimming performance
Swim velocity	-.998**
Stroke length	-.802**
Stroke index	-.925**

**** The required ‘r’ value to be significant at 0.01 level = ‘r’ (13) = 0.641**

Table no. 37 shows that the performance related variables in relation with swimming performance are swim velocity (r = -.998**), stroke length (r = -.802**), stroke index (r = -.925**) were having significant correlation.

Discussion on performance related variables

This study investigated the contribution of selected performance related variables to sprint swimming performance in young male swimmers. The main finding of this study was 100m front crawl swimming performance was significantly correlated to performance related variables swim velocity, stroke length, stroke index.

Previous studies have shown a correlation between swimming performance and performance related variables, such as swim velocity, stroke index (Latt, et al., 2010; Saavedra, et al., 2010; Jurimae, et al., 2007; (Pelayo, et al., 1996; Costill, et al., 1985; Craig, et al., 1985)

The specific training program has a significantly influences on selected motor fitness, anthropometrical, physiological and performance related variables, are well established.

Research scholar had taken this study with a consideration that selected motor fitness, anthropometrical, physiological and performance related variables might have dominant and determinant on performance on swimming.

The finding of the statistical analysis has shown dominant role of selected variables of predictor of free-style swimming performance. Research scholar is of view that the findings have more than justified the purpose, for which the study was mainly taken up.

4.7. Testing of Hypothesis

In hypothesis 1 it is expected that there would be significant improvement on motor fitness variables- muscular strength, muscular strength endurance, flexibility and explosive power of swimmers following specific training.

The findings of the study show that significant improvement on motor fitness variables- muscular strength, muscular strength endurance, flexibility and explosive power of swimmers following specific training. Hence hypothesis 1 is accepted.

In hypothesis 2 it is expected that there would be no significant changes on anthropometric measurements and body composition variables- height, weight, shoulder width, chest circumference, arm span, body mass index, percentage of body fat, total body fat and lean body mass of swimmers following specific training.

Therefore, considering all aspects it may safely be concluded that Hypothesis 2 relating to anthropometric measurements and body composition variables is partially accepted. Hypothesis relating to body height, shoulder width, arm span, body mass index and lean body mass accepted. Relating to body weight, chest circumference, percentage of bodyfat and total body fat it is rejected.

In hypothesis 3 it is expected that there would be significant changes on hematological parameters- red blood cell (RBC), white blood cell (WBC), hemoglobin concentration (HGB), platelets (PLT), haematocrit (HCT) of swimmers following specific training.

The findings of the study show that significant changes on hematological parameters - red blood cell (RBC), white blood cell (WBC), hemoglobin concentration (HGB), platelets (PLT), haematocrit (HCT) of swimmers following specific training. Hence hypothesis 4 is accepted.

In hypothesis 4 it is expected that there would be significant changes on blood lactic acid (before and during exercise) of swimmers following specific training.

The findings of the study show that significant changes on blood lactic acid (before and during exercise) of swimmers following specific training. Hence hypothesis 4 is accepted.

In hypothesis 5 it is expected that there would be significant changes on performance related variables- swimming performance, swim velocity, stroke rate, stroke length and stroke index of swimmers following specific training.

Therefore, considering all aspects it may safely be concluded that Hypothesis 5 relating to performance related variables is partially accepted. Hypothesis relating to swimming performance, swim velocity, stroke length and stroke index accepted. Relating to stroke rate it is rejected.

In hypothesis 6 It is hypothesised that swimming performance would be significantly related to selected motor fitness, Anthropometric, Physiological and performance related Parameters respectively.

Therefore, considering all aspects it may safely be concluded that Hypothesis 5 relating to motor fitness, anthropometric, physiological and performance related parameters is partially accepted.

Chapter-V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

CHAPTER-V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5. 1. Summary

Wisdom of training procedure including adequate physiological, psychological and nutritional techniques for optimizing athletic performance has increased comprehensively over the current century, and indisputably this new learning has made contribution to the overall changes in human sports performance. Major changes of philosophy have included the much earlier initiation of training and spacious increase in the total volume of requisite preparation.

The modern sports training concept as we know it come into the existence during the later period of the 19^{th} century with the firm establishment of National and International games and sports.

Swimming is an individual or team sport that requires the use of one’s arms and legs to move the body through water. Competitive swimming became popular in the 19th century. The goal of high-level competitive swimming is to break personal or world records while beating competitors in any given event. Swimming in competition should create the least resistance in order to obtain maximum speed. However, some professional swimmers who do not hold a national or world ranking are considered the best in regard to their technical skills. Typically, an athlete goes through a cycle of training in which the body is overloaded with work in the beginning and middle segments of the cycle, and then the workload is decreased in the final stage as the swimmer approaches competition.

Sport training is a systematic and scientific process spreading over a long time. For highest achievement the system of training has to be based and conducted on scientific facts and lines where it is not possible to do that, the training has to be based on the results Successful practice which has withstood the test of time sport. The knowledge and information acquired from these sciences have to be brought into actual practice. The sports training principles serve the purpose of applying this knowledge into practice. These principles serve as directives teachers, coaches and sportsperson for formulation, implementation and control of sports training on the basis of knowledge acquired from different training science disciplines. (Harre , 1982), (Matveyev, 1981), (Singh , 1991) have analysed the theoretical basis of training principles and identified the followings as cardinal principles of training. These principles are (i) Progression of load, (ii) Continuity, (iii) Planned and Systematic training, (iv) Individualization, (v) Active participation, (vi) General and Specific preparation, (vii) Clarity, (viii) Cyclicity and (ix) Ensuring results (Singh , 1991).

The goal of sports training is to enhance the sports performance in competition to make more successful in chosen sport. It is the aggregate of both physical fitness and the sports skills. They are based on well scientific principles and proven training techniques to create a customized, effective workout plan. Such a training program, combined with difficult work, will improve quickness, speed, strength, flexibility, agility and stamina.

Muscular strength and endurance are both important for swimming. Strength is the amount of force that muscles are able to produce and endurance is the ability of the muscles to perform repeated submaximal contractions over time. In swimming, muscular strength dictates how much amount force swimmer muscles are able to produce to the water, which in turn propels swimmers' body forward. Swimming alone can positively build muscular strength. The water acts as resistance that the muscles have to overcome. Therefore, with consistent swimming, the muscles accept and become stronger. Those who have been swimming compatible for a period of time, however, will discover that because of their muscle acclimatization, the water resistance no longer gives sufficient of a stimulus to challenge their muscles and improve more strength. At that point, those who are looking to develop their swimming performance can incorporate strength-training exercises into their governance to continue to build strength.

A successful sport engagement demands gradual training from an advance age. Apart from training sessions, in series to succeed in contemporary sport it is essential for an athlete to possess certain genetically conditioned abilities and features. Body composition, anthropometric dimensions, and morphological characteristics play an important role in ascertaining the success of a sportsperson. Contemporary swimmers presuppose the existence of a certain body structure, of strong enduring swimmers marked by high intelligence, controlled aggressiveness, and highly developed functional and motor abilities, with a sense for improvisation and a collective sport. The analyses up to date that have researched anthropometric dimensions point to the fact that contemporary swimming is dominated by swimmers of above-average height compared to the selection pool population, and their build tends to be athletic. The relation between height and body mass is equally important due to the fact that modern swimming sports.

Research findings of a study showed that the athletes' somatotype and anthropometric characteristics are related to the type of each sport. In addition, there is a relationship between high athletic performance and physical characteristics, like height, low percentage of body fat and high muscle mass.

The effect of exercise on the blood volume depends on the type and intensity of exercise, trained condition of sportsperson acclimatization to heat. The endurance training, rest condition blood volume increases approximately by eight percentages. Such an increase is higher intensity of training. Such an increase in blood volume is caused by a 12-percentage increase in the plasma volume and a slight increase in the red blood cells volume (Convertino, et al., 1980). During strenuous exercise in a hot climate, the sweating rate is from 1 to > 2 liter per hour. This increased sweating may reduce the total blood volume by 3 percentages or more (Harrison, 1985).

During exercise in the bicycle, the blood volume decreases (hemoconcentration occurs) in an untrained subject with increasing intensities of exercise during cycling, there will be a greater hemoconcentration. The plasma volume reduces maximally by about 15 percentages which reveals 8 percentages decrease in the total blood volume (Senay & Kok, 1977).

The blood concentration of lactate depends on the rate of diffusion from the muscle fiber into the blood stream. This is a relatively slow process. At normal temperature, peak blood concentrations are reached 1-2 min. after a brief maximal effort. However, the time lag may be prolonged in cold water. The ratio of intramuscular to blood lactate concentration is influenced by the following factors: (a) Total muscle volume that is anaerobically active. (b) Total circulating blood volumes (Shephard, et al., 1989). (c) Proportion of carbohydrate in the diet and thereby the glycogen store. (d) Rate of tissue buffering and the rate of diffusion of hydrogen ion (H+) from the muscles into the blood stream (Hughson & Green, 1982). (e) Rate of metabolism of lactate (Sidney & Shephard, 1973). (f) The blood flow carrying lactate away from the active muscles especially during recovery. (g) Rate of excretion of lactic acid by the kidney and the sweat glands (Lamont, 1987).

Training causes a decrease in the accumulation of lactic acid during a given submaximal exercise. This is an important change, since most work, including that performed during training sessions, is to a large extent submaximal. This factor is illustrated in distance running. This requires submaximal effort over extended periods of time. Not only must these runners have a highly developed maximal aerobic power, but also in order to be successful they must be able to employ a large fraction of that power with minimal accumulation of lactic acid. This allows the runners to maintain a fast pace throughout the race without experiencing early fatigue.

To achieve the competition success at any level of competition, swimmers must include a specific training schedule to maintain or increased strength and power, improve movement pattern and limit the risk of injury (Newton, et al., 2002; Pelot & Darmiento, 2012). The application of muscular force in swimming results in a horizontal displacement of the swimmers at a velocity proportional to the magnitude, and duration of the resulting force. The prime objectives of the mechanical work performed by an athlete are to overcome hydrodynamic resistance, which increased proportionally with the square of velocity. Therefore, any increase in swimming velocity demands a proportional increment of muscular force to overcome active drag and increase propulsive force (Vorontsov, 2011). Increments in muscle strength should theoretically translate into increased ability to generate propulsive force in the water, but theoretical aspects of swimming stroke mechanics was also determined the extent to which increased force transfers into faster swimming velocity (Riewald & Rodeo, 2015; Girold, et al., 2007; Hawley, et al., 1992; Tanaka & Swensen, 1998). In this respect, it is important that dry-land training for swimmers should complement, not replace, sports-specific in water training, and it must enhance, not hinder, the swimmers in water sessions by improving the quality of training. Concurrent training in employed to manipulate the force-velocity curve and the ability to apply large amounts of muscle force under sports-specific conditions. A positive transfer to swimming performance must be achieved through improvements in physical, physiological and biomechanical variables. Upper body strength in particular is imperative in swimming, as most of the propulsive forces and swimming velocity are generated by the upper body musculature (Hollander, et al., 1988; Toussaint & Beek, 1992; Deschodt-Arsac, et al., 1999).

Details of related literature as far as the researcher could collect have been reviewed extensively, parameter wise under the allied and critical review of related literatures and are presented in **chapter II** of this thesis.

The subjects of this study were selected purposively from a group of young male swimmers of the age ranging 14 yrs. to 16 yrs. Fifteen (n=15) male swimmers from Nimpith Vivekananda Sports Association were selected as experimental group. Subjects who were undergoing a coaching programme in swimming under west Bengal long-term non-residence coaching scheme (LTNRCS) have to follow a strenuous conditioning schedule to improve their general as well as specific fitness followed by a coaching schedule for the development of swimming techniques. This training programme continued for a long-time schematic drawing to develop strength, endurance, agility, speed, flexibility, coordination and performance of swimmers.

For the purpose of understanding the effects of specific training program motor fitness, anthropometric measurements & body composition, hematological, blood lactic acid and performance related parameters were considered as criteria. For **<u>Motor fitness variables</u>** – hand grip strength (RH & LH), pull-ups, sit-ups, sit and reach test, standing broad jump were conducted. For **<u>Anthropometric variables</u>** **I. anthropometric measurement-** body height, body weight, shoulder width, chest circumference, arm span **II. body composition dimension**–body mass index, percentage of body fat, total body fat and lean body mass were measured. For **<u>Physiological & Bio-chemical variables</u>** **I**. **hematological parameters** - red blood cell, white blood cell, hemoglobin concentration, platelets, haematocrit, mean corpuscular volume, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration were measured. For **II. blood lactic acid accumulation** – before onset of exercise, end of 75%, 85%, 90%, 95%, 100% of workload were measured. For **<u>Performance related parameters</u>** – swimming performance, swim velocity, stroke rate, stroke length and stroke index were assessed.

Testing took place at three points during the experimental training period April to September (2018); at the beginning of the experimental training period (T1), after 12 weeks experimental training period (T2) and end of the experimental training period (T3). The training programme has been segregated into two parts- dry-land strength-endurance training programme and swimming training programme according to the objectives of the study. All swimmers trained 2 sessions of dry-land strength-endurance training programme Sunday & Wednesday evening) and 5 sessions of swimming training programme (off Monday and Thursday) per week and thus it is possible to quantify exert training load. All subjects were familiarized with the procedures before testing. The subjects had been instructed to refrain from strenuous exercise for forty-eight hours before testing and to avoid food and caffeine intake of two hours preceding the assessments. The details of the programme have already been presented in **Chapter - III** of the thesis.

The data were collected from various tests at three 'states' of training; before onset of training (A1); after 12 weeks (A2) and after 24 weeks (A3). All data were arranged according to 'states;' of training. Mean scores are presented in tabular form and data were duly analysed adopting standard statistical procedure.

Results were discussed and analysed under four heading (1) motor fitness (2) Anthropometric (4) physiological (5) Performance related parameters.

For motor fitness performance in selected tests were concern in may safely be concluded that with the advancement of training fitness status was improved and the subjects scored at a higher rate in most of the test items.

Following training, **muscular strength** (hand grip muscular strength-RH &LH) was improved significantly after the specific training period of young swimmers. **Muscular strength-endurance** (arm and shoulder strength-endurance & abdominal strength-endurance) was improved significantly after the specific training period of young swimmers. **Flexibility** (hip-trunk flexibility) was improved significantly after the specific training period of young swimmers. **Leg explosive strength** was improved after the specific training period of young swimmers.

Following specific training, **Body height** was no significant changed after the specific training period of young swimmers. **Body weight** was decreased significantly after the specific training period of young swimmers. S**houlder width** was no significant changed after the specific training period of young swimmers. **Chest circumference** was increased significantly after the specific training period of young swimmers. **Arm span** was no significant changed after the specific training period of young swimmers.

Following specific training, **Body mass index** was no significant changed after the specific training period of young swimmers. **Percentage of body fat** was decreased significantly after the specific training period of young swimmers. **Total body fat** was decreased significantly after the specific training period of young swimmers. Following training. **Lean body mass** was no significant changed after the specific training period of young swimmers.

Following specific training, **Red blood cell count** was significant changed after the specific training period of young swimmers. **White blood cell count** was significant changed after the specific training period of young swimmers. Following specific training, **Hemoglobin concentration** was significant changed after the specific training period of young swimmers. **Platelet count** was significant changed after the specific training period of young swimmers. **Hematocrit** was significant changed after the specific training period of young swimmers.

Blood Lactic Acid (BLA) was measured to assessed the metabolic adaptation due to training. Following training variation in before onset of BLA was decreased significantly in swimmers. BLA was measured at end of 75%, 85%, 90%, 95% and 100% workload. Following training significant reduction in BLA accumulation was observed in swimmers during end of 75% workload. Similar result was observed in swimmers during end of 85% workload. During end of 90% workload BLA accumulation was significantly decreased in swimmers. Following training significant reduction in BLA accumulation was observed in swimmers during end of 95% workload. During end of 100% workload BLA accumulation was significantly decreased in swimmers. It was further observed that accumulation of BLA was increased with the higher intensity of the exercise but training resulted less BLA accumulation at given workload following training.

Regarding performance related, **Swimming performance** was significantly improved after the specific training period of young swimmers. For, **Swim velocity** was significantly increased after the specific training period of young swimmers. Regrading, **Stroke rate** was no significant changed after the specific training period of young swimmers. **Stroke length** was improved significantly after the specific training period of young swimmers. **Stroke index** was improved significantly after the specific training period of young swimmers.

Regarding swimming performance with motor fitness variables, **hand grip muscular strength (RH)** was significantly correlated with swimming performance, **hand grip muscular strength (RH)** was significantly correlated with swimming performance, **arm and shoulder strength-endurance** was significantly correlated with swimming performance, **abdominal strength-endurance** was significantly correlated with swimming performance, **leg explosive strength** was significantly correlated with swimming performance

Regarding swimming performance with anthropometric variables, **height** was significantly correlated with swimming performance, **shoulder width** was significantly correlated with swimming performance**, chest circumference** was significantly correlated with swimming performance and **arm span** was significantly correlated with swimming performance.

Regarding swimming performance with blood lactic acid accumulation, **BLA end of 85% workload** was significantly correlated with swimming performance, **BLA end of 90% workload** was significantly correlated with swimming performance, **BLA end of 95% workload** was significantly correlated with swimming performance, **BLA end of 100% workload** was significantly correlated with swimming performance.

Regarding swimming performance with performance related variables, **swim velocity** was significantly correlated with swimming performance, **stroke length** was significantly correlated with swimming performance, **stroke index** was significantly correlated with swimming performance.

5. 2. Conclusions

The present study has its own limitations and considering these aspects following specific conclusions are drawn on the basis of the findings.

5.2.1 On Motor Fitness Variables

1. Following specific training program **Muscular strength** (hand grip muscular strength-Right Hand &Left Hand) improved significantly in young swimmers
2. **Muscular strength-endurance** (arm and shoulder muscular strength-endurance & abdominal strength-endurance) was increased significantly was improved significantly after the specific training period of young swimmers.
3. **Flexibility** (hip-trunk flexibility) was improved significantly after the specific training period of young swimmers.
4. **Leg explosive strength** was improved significantly after the specific training period of young swimmers.

5.2.2. On Anthropometrical Variables

5.2.2.1. Anthropometric Measurement

5. Influence of training has resulted no significant changed in **body height** in young swimmers.
6. **Body weight** was decreased significantly in swimmers after following specific training.
7. Influence of training has resulted no significant changed in **shoulder width** of young swimmers.
8. Influence of training has resulted significant improved in **chest circumference** of young swimmers.
9. **Arm span** was no significantly improved in the experimental group after specific training program.

5.2.2.2. Body Composition Dimension

10. Following training, **body mass index** (BMI) was no significant changed in the swimmers after specific training program.
11. Influence of training has resulted significant decreased in **percentage of body fat** of young swimmers.

12. **Total body fat** was decreased significantly after the specific training period of young swimmers

13. **Lean body mass** was no significant changed after the specific training period of young swimmers

5.2.3. On Physiological & Biochemical Variables

5.2.3.1. Hematological Parameters

14. Following specific training program, **Red blood cell count** was significantly increased after twelve weeks and significantly decreased after the end of twenty-four weeks of specific training period.
15. **White blood cell count** was significantly increased after twelve weeks and decreased after the end of twenty-four weeks of specific training period.
16. **Platelets count** was significantly increased after twelve weeks and decreased after the end of twenty-four weeks of specific training period.
17. **Hemoglobin concentration** was significantly increased after twelve weeks and significantly decreased after the end of twenty-four weeks of specific training period.
18. **Hematocrit** was significantly increased after twelve weeks and significantly decreased after the end of twenty-four weeks of specific training period.

5.2.3.2. Blood Lactic Acid

19. Following training, **Before Onset of Exercise, Blood Lactic Acid accumulation** was decreased significantly after the specific training period of young swimmers
20. Influence of training has resulted significantly decreased in **Blood Lactic Acid accumulation end of 75% Workload** of young swimmers.
21. **Blood Lactic Acid accumulation end of 85% Workload** was decreased significantly after the specific training period of young swimmers.
22. **Blood Lactic Acid accumulation end of 90% Workload** was decreased significantly after the specific training period of young swimmers

23. Influence of training has resulted significantly decreased in BLA end of 95% Workload of young swimmers.
24. **Blood Lactic Acid accumulation end of 100% Workload** was decreased significantly after the specific training period of young swimmers.

5.2.4. On Performance Related Variables

25. With the influence of training, **swimming performance** (100m free-style) was improved significantly after the specific training period of young swimmers.
26. **Swim velocity** was improved significantly after the specific training period of young swimmers.
27. No significant changed was observed in **stroke rate** measure due to specific training of young swimmers.
28. **Stroke length** was improved significantly after the specific training period of young swimmers.
29. **Stroke index** was improved significantly after the specific training period of young swimmers.

5.2.5. On correlation study

5.2.5.a. Swimming performance with motor fitness variables

30. **Hand grip muscular strength (RH)** was significantly correlated with swimming performance.
31. **Hand grip muscular strength (LH)** was significantly correlated with swimming performance.
32. **Arm and shoulder strength-endurance** was significantly correlated with swimming performance.
33. **Abdominal strength-endurance** was significantly correlated with swimming performance.
34. **Leg explosive strength** was significantly correlated with swimming performance.

5.2.5.b. Swimming performance with anthropometric variables

35. **Height** was significantly correlated with swimming performance.
36. **Shoulder width** was significantly correlated with swimming performance.
37. **Chest circumference** was significantly correlated with swimming performance
38. 38. **Arm span** was significantly correlated with swimming performance.

5.2.5.c. Swimming performance with blood lactic acid accumulation (BLA)

39. **BLA end of 85% workload** was significantly correlated with swimming performance.
40. **BLA end of 90% workload** was significantly correlated with swimming performance.
41. **BLA end of 95% workload** was significantly correlated with swimming performance.
42. **BLA end of 100% workload** was significantly correlated with swimming performance.

5.2.5.d. Swimming performance with performance related variables

43. **Swim velocity** was significantly correlated with swimming performance.
44. **Stroke length** was significantly correlated with swimming performance.
45. **stroke index** was significantly correlated with swimming performance.

5.3. Recommendations

In the light of findings of the present study the following recommendations have been drawn for the physical education teacher, sports scientists, coaches, exercise experts, sportspersons research scholar and other peoples.

1. The present research was delimited to young male swimmers, the same type of study may be made with female and senior swimmers also.
2. The present research study refers to the particular sportspersons, so a study may be conducted on the other sportspersons.

3. Along with physical exercise training for enhancement of psyche may be included in the training program and observance of psychological parameters may be made before and after training.
4. In the present study was delimited to selected motor fitness, anthropometrical, physiological and performance related parameters. So, the study may be extent to analyzed the swimmer's other important parameters, which directly related performance.
5. Blood lactic acid level may be measured more scientific instrument fore better result in future study.
6. Correctional study among blood lactic acid, oxygen uptake and heart rate may reveal a true picture of physiological adaptations which was not covered in the present study, may be of immensely useful.

The standards of performance differ from place-to-place owing to environment, socio-economic status and emotional conditions, so a study may be conducted on a wider range covering the whole state or county.

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APPENDICES

CERTIFICATE OF PUBLICATION


UGC-CARE Approved Group - II Journal (Web of Science Group)

ISSN/eISSN: 0889-6348

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This is to certify that the paper entitled

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Authored by:

Dinabandhu Naskar

From:

Jadavpur University

Has been published in

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This is to certify that the paper entitled

Effect of Specific Training Program on Selected Performance Related Parameters of Young Swimmers: An experimental Study

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Has been published in

Tierärztliche Praxis, VOLUME 42, ISSUE 4, April– 2022.

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NATIONAL SEMINAR ON

ISSUES AND CHALLENGES IN PHYSICAL EDUCATION AND SPORTS SCIENCES

25th & 26th June, 2016

Jointly Organized by

Department of Physical Education, Vinaya Bhavana, Visva-Bharati, Santiniketan, West Bengal

And

Alumni Committee, Department of Physical Education, Vinaya Bhavana

Certificate

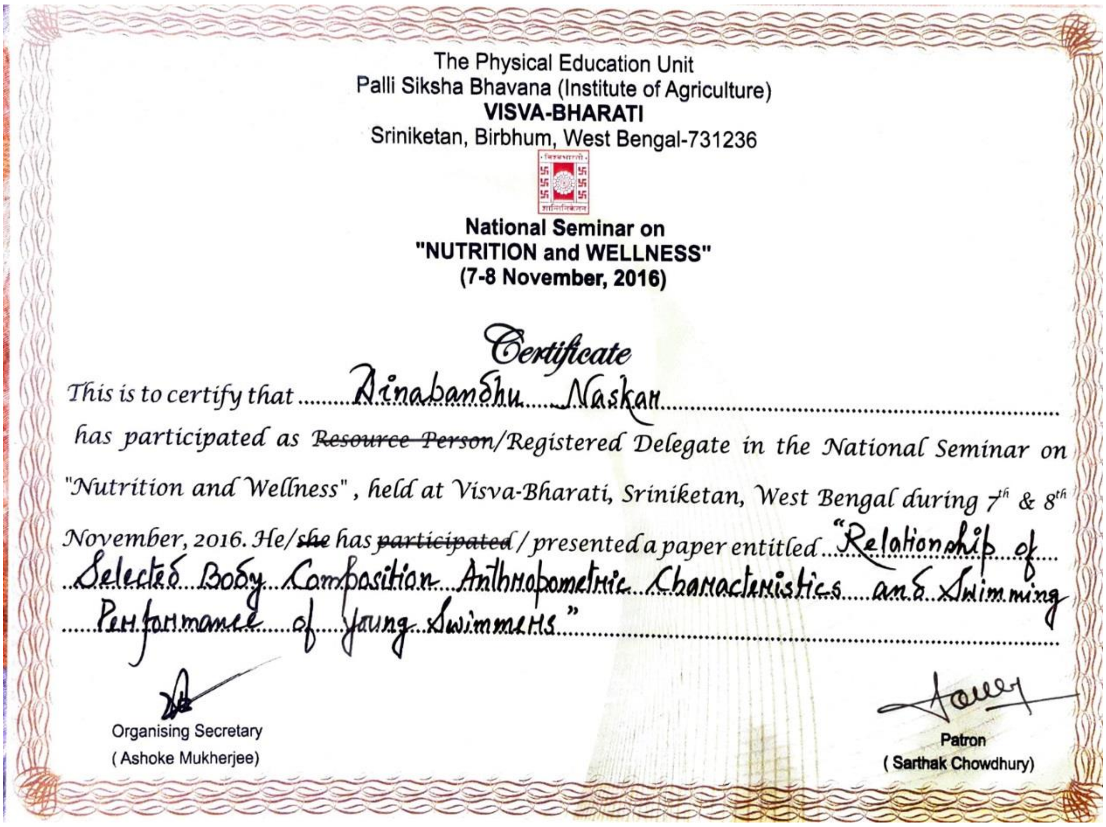
This is to certify that Prof./Dr./Mr./Mrs./Ms. Dinabandhu Naskar

Of Jadavpur University *attended the National Seminar on* ***Issues and Challenges in Physical Education and Sports Sciences*** *as a Resource person/ Chairperson/ Co-Chairperson/ Paper Presenter/ Participant held on 25th & 26th June, 2016 at the Department of Physical Education, Vinaya-Bhavana, Visva Bharati.*

The title of the paper was A study on relationship of selected anthropometric characteristics and swimming performance of junior swimmers

Samiran Mondal	Kamrul	Sen
Prof. Samiran Mondal **Seminar Director & Head** **Department of Physical Education** **Vinaya-Bhavana** **Visva Bharati**	**Md. Kamrul Hasan** **Organizing Secretary & Secretary** **Alumni Committee** **Department of Physical Education** **Vinaya-Bhavana** **Visva Bharati**	**Prof. Sabujkali Sen** **President Seminar Committee & Director** **Studies Education Innovation and** **Rural Reconstruction & Principal,** **Vinaya-Bhavana** **Visva Bharati**

CERTIFICATE OF PRESENTATION



The Physical Education Unit
Palli Siksha Bhavana (Institute of Agriculture)
VISVA-BHARATI
Sriniketan, Birbhum, West Bengal-731236

National Seminar on
"NUTRITION and WELLNESS"
(7-8 November, 2016)

Certificate

This is to certify that Dinabandhu Naskar
has participated as ~~Resource Person~~/Registered Delegate in the National Seminar on "Nutrition and Wellness", held at Visva-Bharati, Sriniketan, West Bengal during 7th & 8th November, 2016. He/~~she~~ has ~~participated~~ / presented a paper entitled "Relationship of Selected Body Composition Anthropometric Characteristics and Swimming Performance of Young Swimmers"

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This is to certify that Prof./Dr./~~Mr.~~/Ms. Dinabandhu Naskar (Research scholar) of Jadavpur University attended the National Seminar on New Horizons of Physical Education and Exercise Sciences as Resource ~~Person~~/~~Chairman~~/Co.-~~Chairperson~~/Paper Presenter/~~Participant~~ held on 20-21 September, 2016 at the Dept. of Physical Education, University of Burdwan.

The title of the paper was A study on Relationship of selected body composition and swimming performance of young swimmers.

Chairman of the Session

Conference Director & TIC
Dept. of Physical Education, The University of Burdwan
Golapbag, Burdwan

CERTIFICATE OF WORKSHOP

7 days International Seminar cum Workshop on
Parental Involvement in the Education and Rehabilitation of Children with Special Needs

organised by **Department of Education, Jadavpur University**, in collaboration with
Arogya Sandhan Charitable Trust, Kolkata & Turnstone Global
17th January to 23rd January, 2017

This is to certify that Dinabandhu Naskar
of Jadavpur University participated in the 7 days International Seminar cum Workshop on ***Parental Involvement in the Education and Rehabilitation of Children with Special Needs*** organised by **Department of Education, Jadavpur University**, in collaboration with **Arogya Sandhan Charitable Trust, Kolkata & Turnstone Global,** on **17.01.2017, 18.01.2017, 19.01.2017, 20.01.2017, 21.01.2017, 22.01.2017 & 23.01.2017**

Secretary Turnstone Global	Head, Department of Education Jadavpur University	Secretary Arogya Sandhan Charitable Trust

CERTIFICATE OF BIOETHICAL COMMITTEE

HURIP INDEPENDENT BIOETHICS COMMITTEE

Ground Floor, 27 Central Road, Kolkata-700032
Ph No. (033) 6450 5885, e-mail : hurip.iec@gmail.com

Date: 05/10/2018

To
Mr. Dinabandhu Naskar
C/O, Professor Sudip Sundar Das
Dept. of Physical Education,
Jadavpur University, Kolkata-700032

Subject: Ethics committee approval of research protocol.

Dear Mr. Naskar,

The HURIP Independent Bioethics Committee reviewed and discussed your application to conduct the research work in relation to your doctoral thesis of the following--

Study Title: "Effect of a Specific Training Program on Selected Motor Fitness Anthropometric and Physiological Parameters of Young Swimmers"

Submitted By: - Dinabandhu Naskar
Full Time Research Scholar,
Dept. of Physical Education,
Jadavpur University

Supervisor: - Professor Sudip Sundar Das
Dept. of Physical Education,
Jadavpur University, Kolkata-700032
&
Dr. Kamal Dutta
Chief Medical Superintendent
Jadavpur University, Kolkata-700032

Submitted study protocol, sample informed consent form and related documents have been approved by the members of the Independent Ethics Committee in the meeting held on meeting held on 05/10/2018 at 4:00 PM in office of HURIP (Ground Floor, 27 Central Road, Kolkata-700032).

HURIP Independent Bioethics Committee expects to be informed about the progress of the study, any SAE occurring in the course of study, any changes in the protocol or informed consent form and asked to be provided a copy of the final report.

Yours sincerely,

5/10/18

DR. P JAISANKAR
Secretary, HURIP

PROF (DR.) A K GHOSH
Chairman, HURIP

1 of 1

CERTIFICATE OF UNIVERSITY MEDICAL OFFICER

যাদবপুর বিশ্ববিদ্যালয়
কলকাতা-৭০০০৩২, ভারত

JADAVPUR UNIVERSITY
KOLKATA 700032, INDIA

শারীর শিক্ষা বিভাগ, কলা অনুষদ / DEPARTMENT OF PHYSICAL EDUCATION, FACULTY OF ARTS

To
Dr. Kamal Dutta
Chief Medical Superintendent
Jadavpur University
Kolkata-32

Through Research Supervisor

Respected sir,

I am Dinabandhu Naskar, regular research scholar, Department of Physical Education, Jadavpur University. My research title is "Effect of a Specific Training Program on Selected Motor Fitness Anthropometric and Physiological Parameters of Young Swimmers", which has been approved by Departmental Research Committee (DRC) held on 07.09.2016 at the Department of Physical Education. I need to collect blood sample from the volunteers for my research work. Blood sample will be collected from swimmers of Nimpith Vivekananda Sports Association, Jaynagar, South 24 Parganas, West Bengal by a reputed pathology lab (Ayush Diagnostic & Polyclinic, Dhakuria Station Road, Kolkata-70001). For the completion of the said research study, it is a mandate to have ethical clearance. For this reason the research design in short is mentioned below for your perusal and approval.

Sir, I will be highly obliged if you kindly approved the research design for the said purpose to continue my research work.

Thanking you

Supervisor
Dr. SUDIP SUNDAR DAS
Professor
Department of Physical Education
Jadavpur University
Kolkata-700 032

Approved
Chief Medical Superintendent
HEALTH CENTRE
Jadavpur University
Kolkata-32

Yours faithfully,

Dinabandhu Naskar
(Dinabandhu Naskar)
Research Fellow
Dept. of Physical Education, JU

Research title: Effect of a Specific Training Program on Selected Motor Fitness Anthropometric and Physiological Parameters of Young Swimmers.

No. of Subjects	Sex	Age	Duration of Training	Blood Samples Collection	Parameters	Lab	Study Area
Fifteen (n=15) swimmer	male	14-16 yrs.	5 months	Two (02) times before onset of the training and after the completion of five months training.	RBC, WBC, Hb, HCT, PLT, MCV, MCH, MCHC and blood lactate concentration	Ayush Diagnostic & Polyclinic (DHAKURA StationRoad, Kol-31	Nimpith Vivekananda Sports Association, Jaynagar, South 24 Pgs. West Bengal

*Established on and from 24th December, 1955 vide Notification No. 10986-Edn/IU-42/55 dated 6th December, 1955 under Jadavpur University Act, 1955 (West Bengal Act XXXIII of 1955) followed by Jadavpur University Act, 1981 (West Bengal Act XXIV of 1981)

Website : www.juphysicaleducation.org
Phone :(033) 2413 6766

PICTURES OF THE DATA COLLECTION

Pic 1: Hand Grip Muscular Strength

Pic 2: Pull-Ups

Pic 3: Sit-Ups

Pic 4: Sit & Reach Test

Pic 5: Standing Broad Jump

Pic 5: Height

PICTURES OF THE DATA COLLECTION

Pic 6: Weight

Pic 7: shoulder Width

Pic 8: Chest Circumference

Pic 9: Arm Span

Pic 10: Triceps

Pic 11: Abdominal

PICTURES OF THE DATA COLLECTION

Pic 12: Suprailiac

Pic 13: Thigh

Pic 15: blood collection

Pic 16: Blood collection

Pic 17: Blood Lactic Acid Accumulation

Pic 18: Blood Lactic Acid Accumulation

SPECIMEN COPY OF BLOOD COLLECTION RESULT

AYUSH DIAGNOSTIC & POLYCLINIC

64/5, Dhakuria Station Road, Kolkata 700031
Mob. : 92315 90336
Ph. : 033 - 4073 5691
ayush.diagpoly@gmail.com

ACCESSION NO.	2018-19/0002419	DRAWN DATE	: 07.04.2018
NAME	**Mast. Kamal Nath Das**	RECEIVE DATE	: 07.04.2018
AGE / SEX	14 Year / Male	REPORT DATE	: 07.04.2018
REF. DOCTOR	Dr. Corporate	CC	: LAB

REPORT ON HAEMATOLOGY

TESTS	RESULTS	UNITS	REFERENCE RANGE
Haemoglobin (Hb)	12.8	g/dL	12.8 - 16.0 g/dl
WBC Count			
WBC Count	7.1	thou/cmm	4.0 - 11.0 Thou/cmm.
RBC Count	5.20	million/cmm	4.5 - 5.5
Specimen : Whole Blood			
Platelet Count	1.32	lakhs/μL	1.5 - 4.1 lakhs/μL
PCV	43.0	%	40 - 45 %
MCV	82.8	fL	81.4 - 91.9 fL
MCH	24.6	pg	(Normal 27 - 31 pg).
MCHC	29.7	g/dL	(Normal 31.5 - 34.5 g/dL).
DIFFERENTIAL COUNT			
Neutrophil	63	%	25 - 75 %
Lymphocyte	34	%	15 - 35 %
Monocyte	02	%	02 - 08 %
Eosinophil	01	%	00 -04 %
Basophil	00	%	00 - 01 %
Morphology : (Blood Smear)			
RBC	Normocytic Normochromic		
WBC	No immature cell seen		
Platelet	Adequate		
Specimen : Whole Blood			
Methodology : Slide			
Abnormal Cells	No Abnormal Cell Found		
Erythrocyte Sedimentation Rate (ESR)	09	mm/hr.	0 - 15 mm/hr.
Specimen : Whole Blood			
Methodology : NA			

** Please correlated clinically.

Dr. Indrani Chatterjee
Consultant Pathologist (MD)

SPECIMEN COPY OF BLOOD COLLECTION RESULT

AYUSH DIAGNOSTIC & POLYCLINIC

64/5, Dhakuria Station Road, Kolkata 700031
Mob. : 92315 90336
Ph. : 033 - 4073 5691
ayush.diagpoly@gmail.com

ACCESSION NO	2018-19/0002418	DRAWN DATE	07.04.2018
NAME	**Mast. Subir Malik**	RECEIVE DATE	07.04.2018
AGE / SEX	15 Year / Male	REPORT DATE	07.04.2018
REF. DOCTOR	Dr. Corporate	CC	LAB

REPORT ON HAEMATOLOGY

TESTS	RESULTS	UNITS	REFERENCE RANGE
Haemoglobin (Hb)	11.4	g/dL	12.8 - 16.0 g/dl
WBC Count			
WBC Count	6.7	thou/cmm	4.0 - 11.0 Thou/cmm
RBC Count	5.82	million/cmm	4.5 - 5.5
Specimen : Whole Blood			
Platelet Count	2.10	lakhs/µL	1.5 - 4.1 lakhs/µL
PCV	42.5	%	40 - 45 %
MCV	84.9	fL	81.4 - 91.9 fL
MCH	17.4	pg	(Normal 27 - 31 pg)
MCHC	26.8	g/dL	(Normal 31.5 - 34.5 g/dL)
DIFFERENTIAL COUNT			
Neutrophil	78	%	25 - 75 %
Lymphocyte	18	%	15 - 35 %
Monocyte	03	%	02 - 08 %
Eosinophil	01	%	00 -04 %
Basophil	00	%	00 - 01 %
Morphology : (Blood Smear)			
RBC	Normocytic Normochromic		
WBC	No immature cell seen		
Platelet	Adequate		
Specimen : Whole Blood			
Methodology : Slide			
Abnormal Cells	No Abnormal Cell Found		
Erythrocyte Sedimentation Rate (ESR)	10	mm/hr.	0 - 15 mm/hr.
Specimen : Whole Blood			
Methodology : NA			

** Please correlated clinically.

Dr. Indrani Chatterjee
Consultant Pathologist (MD)