EFFECT OF DIFFERENT INTERMITTENT HYPOXIC TRAINING ON SELECTED PHYSIOLOGICAL VARIABLES INFLUENCING AEROBIC AND ANAEROBIC PERFORMANCE

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CERTIFICATE

Certified that the thesis entitled **"EFFECT OF DIFFERENT INTERMITTENT HYPOXIC TRAINING ON SELECTED PHYSIOLOGICAL VARIABLES INFLUENCING AEROBIC AND ANAEROBIC PERFORMANCE"** 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 Dr. Gopal Chandra Saha, Professor, Department of Physical Education, Jadavpur University and that neither this thesis nor any part of it has been submitted before any degree or diploma anywhere/elsewhere.

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Dedicated to
My Parents, My
Gurudev, wife,
Teachers,
and Brother

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INTRODUCTION

Overview

Training's ultimate goal is to help athletes perform at a high level across a wide range of sports. Training's ultimate goal is to bring out the best in its participants. Most endeavours cannot be performed at peak efficiency in a single 24-hour period. Efficiency is influenced by a number of different variables. The basic objective of sports training is to maximise one's natural athletic potential. Discipline in the sport is directly related to the fundamental abilities of speed, agility, and coordination. The ability to undertake locomotive actions may be regarded as a pretty steady collection of internal genetic presuppositions. Such traits include, for instance, power, velocity, stamina, coherence, and adaptability (Dreiskämpe et al., 2022). Physical aptitude in sports is one manifestation of this ability. In order to succeed in a sports field with strict rules, it is necessary to develop the requisite sports skills. Developing one's motor skills might aid in the acquisition of various underlying assumptions. However, motivation is crucial for the application of athletic abilities and the growth of motor skills. When we say that something motivates us, we mean that we feel compelled to take action. The list of requirements for effective performance implementation is rounded out by tactical abilities. According to the research of Schnabel et al. (2008), the term "tactics" describes a strategic manner of competing in sports.

Training designed for a certain sport has two main goals: improving fitness and performance. Strength training, rehabilitation, conditioning, and cardiovascular training are all included. Included in the programme is not only physical training but also mental and psychological preparation and guidance on nutritional values. The primary goal of sports training is to improve performance in a certain area. The fundamental objective is to assist athletes in reaching their full potential (Myer et al., 2011). To succeed, you must have the mental tenacity to persevere. The ability to deal with the stress and worry that comes with taking part in sports of all kinds should be developed. Athletes need mental toughness to handle the vast variety of challenges they face during competition. Training plans in this area typically aim to peak at a specific time, therefore they place an emphasis on honing specific motor abilities, agility, strength, or physical fitness. The purpose of military training is to provide recruits with the knowledge and skills they'll need to succeed in combat and survive in a hostile environment. Survival techniques, weapon handling, and evading capture by the enemy are just a few of the many themes discussed (Szivak et al., 2018). As a technique of coping with psychological and physiological stress, relaxation training or autogenic training may be practised by people who feel it is effective. There has been conflicting evidence from studies on the effects of autogenic training on health.

All human activities, by their very nature, have changed over time. How much of a motor job is finished is measured in terms of what is called its "performance." There are no bounds to what constitutes a successful hunt when viewed through the lens of a primordial hunter. Athletes' success in a sport can be understood in terms of the distance they can throw. Efficiency refers to one's potential to obtain a specific result again and over (Schnabel et al., 2008).

The phrase "sports training" refers to the process by which an older athlete's performance in a given sport can be optimised by gradual improvements to the training regimen's many components. Sessions in any given sport will often consist of a variety of elements (Schnabel et al., 2008). See Figure 1.

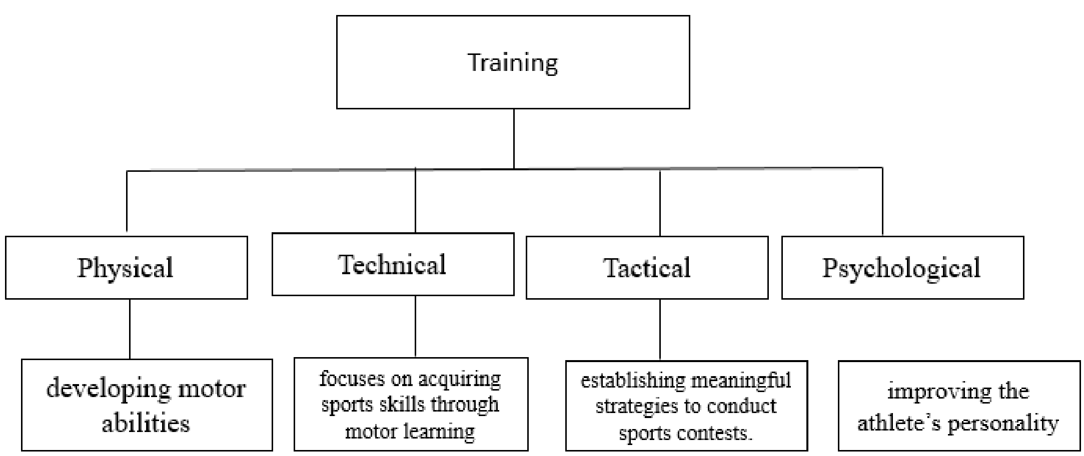

Figure 1: Components of Sports training

A player's skill level is determined by the amount and quality of his or her motor movements. Athletes need to be in good shape, know their stuff when it comes to technique and strategy, and have matured physiologically in order to carry out these motor activities (Kolman et al., 2019). The most crucial aspects of physical fitness are the motor fitness components, which include things like speed, strength, endurance, flexibility, co-ordination abilities, buffer capacity, energy reserves, and the functioning ability of internal organs. A fixed number of each of them is required for movement, independent of the game's ratio. It is possible to quantify many different aspects of physical performance, including force, speed, duration, and range of motion (Kraemer et al., 2004).

"The capacity of the body to take in and use oxygen is critical in many sports, and it is frequently the lone element determining the quality of the performance." Athletes at the highest levels of competition frequently seek out incremental improvements in performance. However, beginners can significantly increase their VO2 max with exercise. Most top-tier athletes aim for incremental improvements each season. In this context of "ceiling," genetics appears to play a crucial impact. With hypoxic training, you can break through that barrier and reap advantages that would ordinarily take years, if they ever materialized at all. The concept of using oxygen-depleted air for purposes such as physical training or medical therapy is not new. Esculapius, the "blameless physician" and "father of hygiene" in Greek mythology, built his temple high in the mountains. A hypoxic atmosphere was exploited by the Indians to make their future leaders stronger than their opponents. People in the Caucasus Mountains have a well-deserved reputation for living long, healthy lives. The gases exchanged during breath holding, the effect of oxygen intake on breath holding time, the repercussions of hyperventilation, and the relationship between barometric pressure and breath holding capacity have all been investigated as part of the study of hypoxic capacity. In a 2009 study (Lindholm et al, 2016).

Councilman (1984) claims that track athletes from the Czech Republic, East Germany, and the United States have used hypoxic training methods like the six-step inhalation. He thinks that it serves little purpose to hold one's breath for an extended time during or after an activity.

Hypoxic studies have revealed five processes by which an organism can adjust to low partial pressures of oxygen (PO2):

- Improved pulmonary air exchange
- Increased levels of the oxygen-carrying hemoglobin
- The lungs have a greater ability to dissipate oxygen.
- Vascularity in the tissues has been increased.

Rapidly increasing lung ventilation is not uncommon after you reach an altitude of 8,000 feet or above. At this height, arterial oxygen saturation reduces to around 93%, at which point chemo receptors begin to activate. One's chemo receptors begin to stimulate ventilation at an altitude of above 8,000 feet, resulting in an increase of about 65% above average if the individual is exposed to the high altitude merely immediately (but numerous days of exposure enhances ventilation by 3000%). Scientific studies lend credence to the idea that an individual's ability to adjust to a new environment is influenced by their immediate context. Training in low oxygen conditions (hypoxia) has been shown to increase strength and endurance by as much as 40 percent (Sun et al., 2005).

Hepatorenal Syndrome (HRS) enhances performance by increasing the amount of oxygen reaching targeted muscles. Hepatorenal Syndrome (HRS) air attacks may be reduced by as much as 50 percent with the help of hypoxic training (Vogt et al., 2010).

In 1969, Jack Daniels and Neil Oldridge looked into the effects of altitude training on peak aerobic power (VO2max) and performance. The effects of altitude training on already highly trained athletes have been studied more since then. Evidence for this can be found in a number of studies (McLean et al., 2014; Robertson et al., 2010; Julian et al., 2003; Buchheit et al., 2012). One of the benefits of altitude training is that it stimulates the kidneys to produce more erythropoietin (EPO), a hormone that increases red blood cell formation (de Paula et al., 2012). Red blood cell (RBC) counts correlate positively with maximal oxygen carrying capacity (VO2max) during exercise (Levine & Stray-Gundersen, 1997).

Early studies found that training in hypoxic settings had no impact on performance. The intensity of training was viewed as a major barrier for athletes competing at high altitude. This might have a deconditioning impact on well-trained and top athletes (Levine & Stray-Gundersen, 1997). The concept of "live high, train low" makes up for this. Athletes can reduce the negative effects of altitude on their performance by increasing their exercise intensity, moving to a lower altitude (1,250 m from 2,500 m), or both. Inspiratory Muscle Training (IMT) is another strategy for enhancing physical performance. In order to determine how IMT affects endurance performance in athletes, an experiment was undertaken with trained cyclists (Romer et al., 2002). After 6 weeks of IMT, patients had better breathing and pulmonary muscle function. Furthermore, in both the 20- and 40-kilometer-time trials, the IMT group significantly outperformed the control group. Results may vary based on the IMT protocol employed, the IMT device employed, and the amount of time spent exercising (Ghanbari et al., 2013), however it is hoped that IMT will increase athletic performance.

Hypoxic Training

Hypoxia training is used to enhance exercise performance at sea level by sports scientists, numerous athletes, and coaches. Training at high altitude can be done in a variety of ways, such as Live High Train Low (LHTL) and Live High Train High (LHTTH). In the field of altitude/hypoxic training, living low training high (LLTH) techniques have grown in popularity in recent years. Athletes who live in low-lying coastal areas may find it beneficial to practise at altitudes between 2,000 and 4,500 metres. The literature supports this view (Faiss et al., 2013a; Girard et al., 2017; Hamlin et al., 2010).

Because Intermittent Hypoxic Training (IHT) often involves less time and amount of hypoxia exposure, it may be of interest to athletes and coaches. This type of hypoxic exposure typically lasts between two and six weeks, with each session lasting less than three hours. (McLean et al., 2014). Combining the physiological stress of hypobaric or normobaric hypoxic exposure with the psychological stress of training may amplify exercise-induced alterations in aerobic exercise capacity (Czuba et al., 2011). Biochemical and anatomical changes in skeletal and cardiac muscles that are more amenable to oxidative activities may be induced by intermittent hypoxic training (IHT). What this means is that IHT has the potential to enhance erythropoietic and metabolic processes, leading to increased red blood cell volume, serum erythropoietin production, higher blood flow, and enhanced exercise economy. Research has shown that this is the case (Czuba et al., 2011; Geiser et al., 2001; Hamlin et al., 2010). The debate continues over whether or not sea-level athletes can benefit from Intermittent Hypoxic Training (IHT) to increase their aerobic exercise capacity. Aerobic capacity may improve during Intermittent Hypoxic Training (IHT) due to enhanced blood oxygen transport or utilisation. Many studies support this (Ponsot et al., 2006; Czuba et al., 2011). A number of research have failed to show that IHT (Beidleman et al., 2009; Katayama et al., 2004; Rodriguez et al., 2007; Roels et al., 2007) improves performance during aerobic activity.

Blood oxygen levels are lowered to the point of hypoxia adaptation in intermittent hypoxic training, with rest periods in between to prevent overtraining. Hypoxia adaptation and the generation of new defence mechanisms cause beneficial physiological changes and clinical consequences when oxygen levels are decreased (Bernardi et al., 2001). These proteins include antioxidant enzymes and heat shock proteins.

By breathing in oxygen-depleted air (normobaric hypoxia), blood oxygen levels can be lowered and tissue hypoxia can occur. Periods of hypoxia are interspersed with periods of normoxia or hyperoxia in a hypoxic regimen known as intermittent hypoxia (IH) or intermittent hypoxia-hyperoxia (IHH) (Susta et al., 2020).

In addition, various researches have revealed that IHT showed no extra anaerobic performance improvements when compared to equivalent training in normoxia (Faiss et al., 2013a; Millet et al., 2014). In order to overcome the major drawbacks of IHT (reduced training stimulus owing to hypoxia), Rectus Sheath hematoma (RSH) is used. This approach significantly improved athletes' anaerobic power (Faiss et al., 2013b; Galvin et al., 2013; Hamlin et al., 2017) by increasing blood perfusion variations in working muscles, molecular adaptations, increased glycolytic enzyme activity, higher muscle buffering capacity, and increased lactate tolerance.

Muscle strength and endurance, as well as the role of metabolites (such as blood lactate, inorganic phosphate, and hydrogen ion), hormones, neuromuscular adaptation, and muscle growth and development in RTH, have been the subject of current research. According to previous studies (Nishimura et al., 2010; Scott et al., 2014), the key causes of RTH's influence on muscle strength and endurance augmentation are the accumulation of metabolites and an enhanced hormone response (testosterone, adrenaline, norepinephrine). Experts are split on whether or not RTH actually increases muscular performance, and the mechanism by which it does so is unclear (Park, 2018).

Recent research has demonstrated that there are no additional benefits to training in normoxia when compared to the positive effects shown with IHT, RSH, and RTH. It's possible that methodological discrepancies are to blame for the incongruous results found in research examining the efficacy of hypoxic training in enhancing sea level muscle function, aerobic exercise capacity, and anaerobic power. However, it's also possible that a number of other factors are at play here to get similar results. It has been shown that hypoxia training is more effective when carried out in accordance with established training protocols (Park et al., 2016).

Since competitive swimmers participate in nearly every event requiring aerobic exercise capacity, anaerobic power, pull and push muscular strength, and upper limb endurance, it would be useful to explore how RTH, IHT, and RSH affect normoxic exercise performance.

They put up a lot of labour and train hard to improve their endurance, strength, and swimming speed in water (Moschovis et al., 2016).

Aerobic exercise, as defined by the American College of Sports Medicine (ACSM), involves the usage of large muscle groups, has a steady heart rate, and may be performed for extended periods of time. Muscles that engage in aerobic metabolism naturally create ATP since it may be synthesised from amino acids, glucose, and fatty acids. Aerobic activities like cycling and dancing are great examples. Other examples of aerobic activities include: hiking, jogging, swimming, and walking. The American College of Sports Medicine (ACSM) says that the optimum method to take part in these activities is to make use of your aerobic capacity, which is the sum of your heart rate and your body's ability to take in oxygen through your skeletal muscles. Peak oxygen consumption (VO2) is the gold standard for determining aerobic capacity, and it may be determined using a variety of approaches, including treadmill protocols, oxygen consumption, and graded exercise ergometry, analyzers, and even mathematical calculations. Peak VO2 was calculated in conjunction with other factors in a study by Vaitkevicius et al. (1993), and the researchers found that higher physical conditioning was linked to lower arterial stiffness. This finding suggests that peak VO2 is important. Athletes at sea level can benefit from training to increase red blood cell mass and improve oxygen transport in hypoxic (low oxygen) circumstances. Training masks have no effect on athletes' haemoglobin or hematocrit levels since they do not alter the oxygen content of the air athletes breathe in (Park, 2018).

However, it appears that they cause an adaptive physiological response in the form of increased respiratory muscle resistance by reducing oxygen delivery. Athletes should train their diaphragms, intercostals, and the skeletal muscles that support them in the same way that they train any other muscle group. It was created with the sole intention of strengthening the respiratory muscles. RMT, or respiratory muscle training, is one method of conditioning. Respiratory muscle training (RMT) has been shown to dramatically improve athletes' strength, velocity, and endurance. Preoperative Inspiratory Muscle Training (IMT) and Respiratory Muscle Training (RMT) are used to reduce the risk of postoperative pulmonary complications in patients undergoing cardiac or abdominal surgery. You may improve your respiratory muscle fitness at any time and in any place by using a training mask. Because of the devices' capability to restrict the user's breathing, the user's cardiorespiratory fitness can be increased. Great athletes may be held back by their lungs (Sheel et al., 2002).

Reflexive muscle training (RMT) has been shown to benefit athletes in a number of ways, although its benefits on performance remain unclear. Gigliotti et al. (2006) conducted a comprehensive literature review and found that RMT increases important performance indicators; however, the mechanisms underlying these gains are not fully understood and require further exploration.

Types of IHT (Intermittent Hypoxic Training):

IHT may be approached in a variety of ways. They may be categorized into three groups:

- **Short intervals of hypoxic exposures or Intermittent Hypoxic Training (IHT)**
  Resting hypoxia exposure consists of 3-5-minute periods of exposure to low-oxygen air, followed by periods of exposure to normal air (for example, reading or watching TV). The standard hourly pattern consists of 5 on and 5 off periods. During this process, a fingertip pulse oximeter is used to quantify the percentage of oxygen in the blood. Maintain an oxygen saturation level in the blood of 80 to 85 percent while wearing the mask and 95 percent or higher when it is removed. Short-term exposure to hypoxia at high elevations has been demonstrated to improve acclimatisation, high-altitude tolerance, and the ventilatory response (lung capacity) (Mujika et al., 2019).
- **Hypoxic exposure during high-intensity exercise or Intermittent Hypoxic Exercise (IHE)**
  Recent studies have shown that short bursts of high intensity exercise are more effective than longer periods of moderate activity in boosting athletic performance. Low-oxygen conditions, such as during exercise, improve the effectiveness of interval training. The altitude mask is used only during intervals, and the mask is removed upon recovery. Recovery times after an interval are typically between two and three minutes long. Improvements in athletic performance at sea level and at altitude have been linked to short-interval hypoxic exposure during high-intensity exercise, which alters molecular processes in skeletal muscle tissue and increases the ventilatory response (lung capacity) (Balsom et al., 1994).
- **Steady Hypoxic Workouts (Aerobic)**
  Although not technically IHT, steady-state aerobic hypoxic exercise is included for comprehensiveness. A hypoxic workout entails using a mask to exercise on a cycle trainer or treadmill in low-oxygen air. When compared to shorter bouts, the duration

of an aerobic hypoxic exercise can be anywhere from 15 minutes to an hour or more. Training for extreme altitudes, such as mountaineering. To simulate the effects of being at a high altitude, hypoxic exercises could be performed. (Young, 2018)

Hypoxic Training Method Followed to reach high level performance

Building endurance for competitive swimming can be done in a variety of ways, including slow continuous, Fartlek, slow interval training, and fast interval training. The proper application of these methods has the potential to increase VO2 max. A greater VO2 max may lead to greater endurance. Swimmers can improve their speed with repetition training and sprints, but combining the two in periodization yields good results but not always the kind that win medals or give swimmers an edge in competition. The margin of error for Olympic and World Championship times in swimming is less than one hundredth of a second. Germany's swimmer, who ended 9" to 16 places behind the field at the 1984 Olympic Games in Los Angeles, broke his own national record and the world record in the 400-meter freestyle at the consolation final held for the last eight swimmers in that race. Therefore, elite swimmers in different categories rely on a few interrelated strategies that are essential to their success. It's possible to train in hypoxia. The term "hypoxic training" is used to describe the routine of swimming a set distance while breathing heavily. When swimming, you should only stop to breathe every two, three, or four strokes, at most. Initially, this technique was employed to simulate swimming at elevated elevations. It was argued that slowing one's breathing rate would lead to hypoxia similar to that found at extremely high altitudes. We now know that our first supposition was inaccurate. There is no decrease in the tissue's availability of oxygen during hypoxic training (Lofthus et al., 1980; Stager et al., 1985;).

Although some investigations showed a decrease in alveolar O2, it was not enough to simulate circumstances at high altitude. Whether it's due to the undiscovered benefits of hypoxia training or the effort and dedication it requires from swimmers and coaches, hypoxic training is gaining popularity despite the difficulty of swimming with reduced breathing. Physiologists have linked hypoxic exercise to the development of Hypercapnia. Hypercapnia, or an increase in carbon dioxide rather than a reduction in oxygen, makes it harder for swimmers to hold their breath during competitions. Athletes can, therefore, train in hypoxic environments to learn to restrict their breathing during competition. For this reason, hypoxic training (Hamlin et al., 2010) should be incorporated into every athlete's routine.

Elevation training

The ascent is practised at great heights (between 20,000 and 30,000 feet). At higher altitudes, less oxygen reaches your muscles during exercise, making it simpler to adjust to the "thinner" air. When elite athletes do this, they are able to perform better at lower altitudes (Tayor et al., 2021).

When you workout at a higher altitude, your body has to work that much harder. This fatigue is due to the lack of oxygen caused by being at a high altitude. The lack of oxygen prevents fuel from being burned and energy from being produced, leading to weariness (Balke et al., 1965).

Your body will adjust to the higher altitude by producing more red blood cells while you train there. Your muscles will be able to exert more force as a result of the higher oxygen content in the blood. One to two percentage points of increase in performance may make all the difference while competing (Tayor et al., 2021).

There are many benefits to training at high altitude, especially for elite athletes. Using a training mask and standing on a platform while exercising may help elite athletes get a competitive edge (Sellers et al., 2016).

The "live high, train low" strategy is utilised by some athletes who compete at high altitudes. If you make your home at a high altitude, you'll eventually become used to the thinner air. While competing at a lower altitude, your muscles will benefit from the improved oxygen supply and have more energy to expend.

Performance at lower altitudes may be improved by exercising in either natural or artificial altitude circumstances, by training at numerous altitudes, or by using a high-altitude training mask. Several researchers (Colak et al., 2021)

Elevation training mask

A new product named ETM 2.0 (Elevation Training Mask) from Training Mask LLC in Cadillac, Michigan claims to simulate the effects of altitude training. The ETM mask, which can be worn over the mouth and nose, is equipped with a variety of aperture sizes and flux valves. Oxygen masks have apertures and flux valves that can be adjusted to increase the barrier to breathing. The system's multiple resistance levels allow users to reportedly simulate altitudes between 3,000 and 18,000 feet. According to the company's website (trainingmask.com), the mask has been shown to have positive effects on a variety of respiratory metrics, including maximum oxygen consumption (VO2 max) and endurance..

Figure 2. Elevation Training Mask.

There is evidence that using an altitude training mask (sometimes called a ventilator training mask) can improve athletic performance in a number of ways. In addition, the norm baric hypoxic state that the ETM is meant to produce might be thought of as a simulation of being at a high altitude. The ETM can simulate high-altitude training by adjusting the resistance during inspiration while keeping the resistance during expiration constant (from 914m to 5,486m). The flux valves in the design of the mask restrict the amount of air that can enter the mask, so decreasing the amount of oxygen that may reach the respiratory organs. Some research suggests the gadget can help athletes increase their VO2max, lung capacity, and overall endurance. Some of the most frequently heard claims about the benefits of ETM relate to increased stamina, endurance (aerobic performance), and respiratory muscle strength (anaerobic performance). The Elevation Exercise Mask 2.0 is a reliable tool for high-altitude practice. You can easily adjust the mask's intensity throughout a large range by adjusting the airflow through the intake valves and air-restriction caps (1-hole caps) (Devereux et al., 2021).

The Training Mask is not only useful for athletes preparing for high-altitude sports and mountaineering, but for athletes of all disciplines. Wearing the mask allows you to:

- Create pulmonary resistance to strengthen the lungs.
- The diaphragm should be bolstered
- Enhance elasticity and surface area in alveoli
- Intensify airway resistance
- Anaerobic thresholds should be raised
- Allow for a shorter exercise (*Why You Need a Training Mask For Exercising?*, 2023).

Scientific evaluation of the Elevation Training Mask 2.0 by the American Council on Exercise and the Northern Alberta Institute of Technology. The central hypothesis is "Diaphragm Resistance Technology," which is based on science. The mask compels you to take more substantial breaths, which in turn improves your lung capacity during exercise. The higher resistance trains your lungs to work more efficiently, allowing you to take in and release more oxygen. In the long run, you'll reap the benefits of increased stamina and strength in your lungs and diaphragm (Amirshaghaghi et al., 2022).

The silicone construction of the Elevation Training Mask 2.0, which covers only the nose and mouth and does not obstruct vision, is available in three sizes. Over the silicone part is a new strap that is both breathable and comfortable. An effective cleaning spray, such as Elevation Mask Cleaning Spray, makes trash removal a snap. The Elevation Training Mask is a crucial piece of fitness gear that will greatly improve the quality of your workout. The "Training Mask Exercises" are not something you must learn. There are, however, a few details to remember. It's possible that getting used to the mask will require some time. Before undertaking any additional workouts, beginners should begin at an elevation of 3,000 feet and practise fundamental deep breathing and walking for many minutes at a time (Brian et al., 2022).

The concept of using a hypoxic mask had a rocky start when BALCO founder Victor Conte created the first one for sale to the public. The linked face straps gave it the appearance of a dirty old bar towel, which is how Conte is generally regarded in the athletic world. Contrary to what was claimed, Conte products were typically shown to be ineffectual or at best ineffective (Volkov et al., 2019).

We later found out that the secret to his players' success was actually medications, specifically ZMA (zinc magnesium aspartate) (Willoughby et al., 2003).

Strengthens the respiratory muscles

Due to the potential direct stress on respiratory muscles posed by the peripheral air resistance it produces, the Elevation Training Mask (ETM) more closely resembles a Respiratory Muscle Training (RMT) device. In principle, RMT may boost lung capacity and oxygen efficiency over time, but it would also wear out the respiratory muscles. Some research suggests that RMT may promote oxidative adaptations, which in turn may improve respiratory muscle endurance and delay the onset of metabolic acidosis. A reduction in blood lactate levels and a reduction in the sensation of respiratory exertion following RMT may contribute to a gain in physical performance (Kon et al., 2010).

Wearing the ETM has the potential to significantly increase both the ventilator threshold (VT) and the power output. There has been no change in haematological parameters before or after training. This demonstrates that the ETM behaves more like an RMT than a tool for replicating high-altitude training. Despite this, the data on RMT's efficacy in enhancing athletic performance is mixed. Improvements in RMT do not appear to affect VO2max or endurance exercise performance. Very little is known about the effects of RMT on exercise performance and respiratory parameters (Fernanda et al., 2016).

Aerobic performance

Numerous studies have found that aerobic exercise boosts cardiovascular health. In 2002, they were the first to show that aerobic exercise can help cardiac tissue recover after ischemia. Female Sprague-Dawley rats were used to investigate the effects of exercise on both exercise controls and MI induction. There was a 15% decrease in LV (Left Ventricular) hypertrophy and an 11% decrease in myocyte length and a 20% decrease in myocyte breadth after aerobic training following infarction. Furthermore, the training group demonstrated a 60% increase in ventricular contractility, indicating enhanced myocardial Ca2+ sensitivity. Aerobic exercise was found to improve cardiac remodelling and myocardial contraction in the long run (Garza et al., 2015).

The effects of aerobic exercise on human subjects were validated in a second five-year study by Wisliff and colleagues, but this time there were no human volunteers involved. Participants can choose from three different training options: moderate continuous training (MCT), aerobic interval training (AIT), or no training at all (control group). Ca2+ reuptake rose by 60% from muscle fibres in the AIT group, leading to a 46% improvement in VO2max. Similar to the findings of animal studies, myocardial remodelling was observed in humans during diastole and at the conclusion of systole. The AIT group had a 35% increase in systolic function, proving once again the positive effects of aerobic exercise on health (Fu et al., 2013).

Aerobic exercise has been linked to numerous improvements in cardiovascular health. High-density lipoprotein (HDL) cholesterol and overall lipid profiles have both been shown to improve with regular aerobic exercise. Total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and triglyceride levels all decreased by 0.08 mmol/L to 0.10 mmol/L after aerobic exercise, according to studies conducted in Australia. Aerobic exercise led to a rise of about 0.05 mmol/L in HDL-C levels. Adolescents and children have had similar consequences, too. Aerobic exercise raised HDL-C by 9 percent and lowered TG by 11 percent in a meta-analysis by Kelley and colleagues, but it did not raise total cholesterol or low-density lipoprotein cholesterol much. In a 2014 study (Gordon et al., 2013)

Several recent investigations have shown that aerobic exercise is linked to biochemical signal indicators like Endothelin-I (ET-1). Vasoconstrictor and promoter of atherosclerosis, ET-1 is secreted by vascular endothelial cells. Maeda et al. found statistical evidence for a positive linear relationship between ET-1 and age. After three months of regular aerobic exercise, ET-1 levels drastically decreased. Aerobic exercise may have positive effects, but only within reasonable parameters. A "U-shaped connection" was recently revealed between aerobic exercise and mortality in a research conducted in Denmark. Researchers concluded that the health benefits of aerobic exercise can be maximised with 2–3 sessions per week lasting 1–2.4 hours each. They found that once persons reached a specific level of activity, their mortality risk was no different from that of sedentary adults (Patel et al., 2017).

According to the American College of Sports Medicine (ACSM), anaerobic exercise consists of brief, high-intensity bursts of physical activity that are powered by the energy stored in the athlete's contracting muscles rather than oxygen from the air. When there is little oxygen available, our cells resort to fermentation and glycolysis to generate energy. The creation of lactic acid during this process lowers ATP generation. Sprinting, HIIT, powerlifting, and other high-intensity interval training (HIIT) workouts involve fast-twitch muscles and are hence called anaerobic. In other words, anaerobic exertion leads to a steady increase in lactate and metabolic acidosis. The anaerobic threshold (AT) is the point at which aerobic metabolism is switched off. Blood lactate levels can be examined with regular blood samples during a progressive exercise plan and used to detect AT. The beginning of the curve's sharp ascent on the graph represents the AT.

- **Elevation mask in aerobic training**

Limiting air intake when wearing a mask is not the same as decreasing the partial pressure of air when rising. No one with any understanding of physiology will embrace the claim that elevating masks may enhance haemoglobin. With an elevation mask, the air pressure entering the lungs remains constant while the volume of air entering the lungs decreases. Just picture yourself trying to run a 100-meter dash with a pillow tied to your face or through a straw. Restricted-air training, or "inspiratory muscle training," is what you're doing here. Chronic obstructive pulmonary disease (COPD) patients have found great effectiveness and widespread acceptance of inspiratory muscle exercise. As a result, one's ability to undertake physical exercise may be strengthened (Kraemer et al., 2007).

Your endurance performance is limited not by the amount of air you take in, but by the amount of oxygen in the air and how you take it in. Working out in low oxygen levels has little effect on acclimatisation to high altitudes; rather, it improves the strength and endurance of your respiratory system. Numerous studies have demonstrated that training the athlete's inspiratory muscles improves their respiratory function. Real-world exercise performance is unaffected by hypoxia training or training for the inspiratory muscles. Since your heart rate and breathing rate will both increase during hypoxic training, and since your lactate reaction to submaximal activity will be amplified, you can expect to feel more fatigued than usual. There's nothing surprising here. If you deprive your body of oxygen, it will have to work much more to complete the same activity. Training wearing the mask will limit your range of motion and prevent you from getting a good workout, according to a review by Klusiewicz et al. (2008).

Even while wearing a mask forces you to develop stronger diaphragm muscles and exhale more forcefully, this has no positive effect on your aerobic capacity or endurance. Take a look at some of the top marathon runners: They need a high rate of metabolic efficiency if they are to achieve their goals. Performance might be impaired by an increased diaphragm strength and an increased pace of breathing. In any case, it's safe to presume that one of your key ambitions is to become more physically fit. Train hard to raise your hydrogen ion buffering capacity, VO2 max, and lactate threshold. Strength training can improve endurance by raising one's base strength, power, and speed. The use of training masks had no effect on any of these beneficial changes. Riganas, et al. (2008).

Anaerobic performance

Anaerobic exercise has potential heart health benefits similar to those of aerobic exercise. The effects of anaerobic exercise on C-type natriuretic peptide (CNP) were investigated in a Turkish study by Akseki Temur and colleagues. CNP, generated by the endothelium, affects blood vessel tone and possesses antifibrotic and antiproliferative effects. Blood arteries dilate and flow more easily when the smooth muscle layer is hyperpolarized. It has been found that CNP inhibits cardiac fibroblast growth via the cyclic guanosine monophosphate (cGMP) pathway, suggesting that CNP has anti-proliferative effects on cardiac fibroblasts. Twelve young, healthy males participated in the study, and they were randomly assigned to one of two groups based on their previous levels of physical activity. When the participants were divided into smaller groups, they were given a 30-second anaerobic exercise routine to complete. The levels of the physiologically inactive peptide CNP's amino terminus proCNP (NT-proCNP) were measured in blood samples taken from patients at 1, 5, and 30 minute intervals. At the 5-minute point, those who engaged in anaerobic exercise saw a statistically significant increase in NT-proCNP levels (Patel et al., 2017).

Studies have shown that anaerobic exercise has a similar effect on lipid metabolism as aerobic exercise. Aerobic exercise followed by anaerobic training was found to be more helpful than aerobic training alone in a small European study involving 16 obese participants. Non-esterified fatty acids can be lowered by engaging in either aerobic or anaerobic exercise. The same group also showed the greatest reduction in Body Mass Index (BMI). There are rumours regarding the detrimental repercussions of such a training plan. Manshouri et al. of Iran found one such fault in the form of a substantial decrease in Human Growth Hormone (HGH) levels due to anaerobic exercise. Long-term growth hormone (HGH) deficiencies have been linked to an increased risk of cardiovascular disease and death due to the onset of atherosclerosis at a younger age. Hypertension, obesity (measured by the Body Mass Index or BMI), elevated triglyceride levels, and low levels of good cholesterol (measured by HDL-C) have all been associated to a lack of human growth hormone (HGH). HGH-deficient patients have reduced left ventricle (LV) posterior wall thickness, LV mass index, and LV ejection percent, which may suggest a concern with the structural integrity of the heart Left Ventricular Ejection Fraction (LVEF). We don't know exactly how these shifts occur, but that may alter in the future. To wit: (Patel et al., 2017).

Anaerobic exercise, whose name comes from the Greek word for "without oxygen," uses a different mechanism to break down glucose in the body. This means that anaerobic exercise is more challenging yet takes less time for the ordinary person. Glycolysis, a process that occurs during exercise and is part of the biochemistry of anaerobic exercise, converts glucose to ATP (the primary source of energy for cellular functions). Lactic acid accumulates more quickly because it is produced at a greater rate during anaerobic activities. Muscle fatigue is aided by the accumulation of lactate above the anaerobic threshold (or lactate threshold) (Patel et al., 2017).

Elevation mask in anaerobic training

Both altitude masks and weightlifting are common but dangerous practises that people often engage in. Take a high-rep squat routine as an illustration. A set of 15–20 squats takes about 20 seconds. Since short bursts of intense work don't necessitate a lot of oxygen, this shouldn't be a problem. However, wearing a mask when lifting will undoubtedly decrease performance due to the restricted ventilation (Campo et al., 2015).Short, shallow breaths instead of deep, quality breaths in rhythm with each component of the lift (concentric or eccentric) do nothing to stabilise or manage the weight. Athletes are unable to inhale sufficiently to increase intra-abdominal pressure and support the torso during a Valsalva Manoeuvre. There is no data to suggest that using an elevation mask in conjunction with weight training is beneficial. You can lift heavier weights and complete more reps when you don't have to worry about restricting your air supply (Fairman et al., 2020).

- **Increases strength and power (anaerobic performance)**

According to this notion, oxygen restriction may lead to adaptations that boost buffering capacity, and consequently, Elevation Training Mask (ETM) may help athletes perform better during high-intensity interval training and strength training. There is currently insufficient research to determine whether or not the ETM will impede exercise intensity levels necessary to generate these adaptations. The use of this supplement tends to reduce peak velocity during bench press and back squat workouts, which may have a long-term detrimental influence on training results (Scott et al., 2014).Strength training in hypoxic conditions may improve performance in terms of muscle growth and power, and this possibility has recently been investigated. Increases in maximum strength may also result from hypoxia exposure during resistance training, as this has been shown to encourage the recruitment of advanced fibre types.However, research into the effects of ETM on strength and power performance in conjunction with strength training is very limited. During a strength training session, wearing the ETM seems to have a negative affect on the athlete's capacity to sustain working velocity, as well as their ability to concentrate on the job at hand (Warren et al., 2017).In addition, it is hypothesised that people who regularly participate in aerobic activities live longer, are more productive during their working lives, and have greater levels of optimism, life satisfaction, positive affect, and quality of life throughout their lifespans. Despite its significance, athletes often neglect to engage in loading and adaptation training, which can have a significant impact on their aerobic performance (Sanchez & Borrani, 2018).The scholar was driven to investigate the magnitude of variation in order to ascertain the effect of intermittent hypoxia training on specific physiological indicators. It may pave the road for adults to increase their aerobic capacity, giving them better chances to participate and advance to the top levels of their sport (Tadej et al., 2010).

Statement of the problem

The Purpose of this Study was to investigate the **''Effect of Different Intermittent Hypoxic Training on Selected Physiological Variables Influencing Aerobic and Anaerobic Performance''.**

Objectives of the study

Since the researcher designed a comprehensive study to look at how various intermittent hypoxic training regimens affect the physiological variables of physically fit people.

The objectives of the study were

- To investigate the physiological effects of intermittent hypoxic training in variables such as VO_2 max, Maximum Pulse Rate, Resting Pulse Rate, blood-oxygen saturation level, Fatigue Index among male individuals.
- To examine the impact of sporadic hypoxic training on specific haematological variables in males, such as HBG, MCH, and RBC.

Hypotheses

- **H_0:** It was hypothesized that there would be no significant improvement due to intermittent Hypoxic training in selected Physiological variables such as VO_2 max., maximum pulse rate, blood-oxygen saturation level, fatigue index and resting pulse rate among male individuals.
- **H_0:** It was further hypothesized that there would be no significant improvement due to intermittent Hypoxic training in selected Hematological variables such as HBG, MCH, RBC among male individuals.

Delimitations

- 30 male members of the Beraboni club served as participants in this investigation.
- Participants age was between 18 and 22 years with the majority falling somewhere in the middle.
- The training session was delimited to eight weeks.
- Every member of the masked group used an elevation training mask in this investigation.

Limitations

To understand the study's findings, the following limitations was considered:

- The respondent's prior experience in sports and games was not considered, which might have an impact on training and statistics.
- There was no control over psychological aspects, such as eating habits, sleeping patterns, and lifestyles.
- Temperature, humidity, and other weather variables was not considered during testing and training times.

Definition and Explanation of the Terms

1 **Training-** The goal of training, a pedagogical process based on scientific principles, is to better prepare athletes for competition. Its main objective is to enhance the general health and wellbeing of sportsmen. (Smith, 2023)

2 **Hypoxic Training**- Workouts with low oxygen content are known as hypoxic, and they improve the efficiency of the oxygen delivery system, leading to gains of up to 40 percent in strength and endurance. (Leijnse et al., 1998)

3 **Intermittent hypoxic training-** Living and training at sea level, then living and training at high altitudes, all without having to physically go to the mountains, is what's involved in intermittent hypoxic training, also known as intermittent hypoxic exposure, or IHE for short. (Lundby et al., 2018)

4 **Physically Fit Individuals-** It is a state of total well-being and joy. The phrase "physical fitness" refers to the body's ability to function well during work and leisure activities, to stay healthy, to fend off illness, and to react appropriately in an emergency. (ACSM, 2018)

5 **Elevation training mask-** A patent (PAT.8.590.533 B2) has been awarded to the Elevation Training Mask, a "ResistanceTraining Device" that helps train the lungs by strengthening the diaphragm and creating pulmonary resistance. You will be able to better control your breathing with the aid of the Elevation Training Mask, which will also help you boost your lung stamina, lung capacity, oxygen efficiency, and general mental concentration. Your total performance in any sport or activity, as well as in everyday life, may be improved by using a training mask. (Laursen et al., 2013)

6 **Resting pulse rate-**The number of times that the heart beats in one minute when there is no activity whatsoever. (Tanaka et al., 2000)

7 **Max pulse Rate-** The heart's age-related maximal heart rate, which is often calculated as 220 minus the patient's age, is measured in beats per minute. (Tanaka et al., 2001)

8 **VO_2 Max-** The maximum or ideal pace at which the heart, lungs, and muscles can efficiently use oxygen during exercise is what determines an individual's aerobic capacity. (Poole et al., 2017)

9 **Fatigue Index-** The difference in the amount of power that can be produced by a muscle during repeated loading and unloading of that muscle compared to the amount of power that can be generated by same muscle at peak exercise. (https://medical-dictionary.thefreedictionary.com/fatigue+index**). (**Chalder et al., 1993**)**

10 **Hemoglobin-** The protein known as hemoglobin, which is found in red blood cells, carries carbon dioxide out of the body's tissues and organs and oxygen into them. (Guyton et al., 2021)

11 **Blood Oxygen saturation-** This determines the total quantity of haemoglobin that is present in the blood. The molecule known as hemoglobin, found in red blood cells, is in charge of carrying oxygen from your lungs to the rest of your body. The percentage of oxygen-rich haemoglobin in the blood compared to the total amount of haemoglobin (including unsaturated and saturated forms) is referred to as the oxygen saturation. (West, 2012)

12 **RBC-** Erythrocytes, often known as red blood cells (RBCs), are the most prevalent kind of cell found in the human bloodstream. They are unique among the many types of human cells in that they play a role in the circulation of oxygen throughout the body and possess characteristics that set them apart from the others. (Guyton, 2021)

13 **MCH**- The mean cell haemoglobin, often known as MCH, is an indicator that may be determined using red blood cells (RBCs). This index provides an estimate of the average quantity (in pg) of haemoglobin that is present in the red blood cells. (Macdougall et al., 2021)

Significance of the study

- The aim of physical education research is to support physical education instructors and coaches in enhancing their athletes' and players' performance through innovative training methods.
- The research would provide fresh information to our understanding of sports training.
- The research would provide fresh information to our understanding of sports training.
- Physical Educators and Coaches would be able to use the findings of the research as a guide for developing practise regimens.
- The training with intermittent hypoxia will assist to strengthen the influence of physiological variables on persons who are physically fit.
- The performance of physically fit persons will also be improved as a result of this research, both in terms of their aerobic and anaerobic capacities.
- The future researcher will be able to understand the mechanism by which hypoxic training with elevation training mask (ETM) improves athletic performance.
- The research would provide fresh information to our understanding of sports training.

CHAPTER II

REVIEW OF RELATED LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Researching the relevant literature is a vital step to getting an accurate picture of what has been done and stated in the past. An in-depth assessment of all relevant material provides a comprehensive picture of the field's total collection. It gives the reader a solid foundation for grasping the topic at hand. Understanding the issue and comprehensive the findings are aided by reading relevant literature. This chapter includes a few studies that the author acquired from the library and the internet.

2.1 Studies related to aerobic training

Selvalakshmi (2007) investigated the impact of aerobic exercise on obese women employed by the company based on their weight. The purpose of this study was to compare the cardiovascular and respiratory functions of two randomly selected groups of overweight women employed by IT companies. Overweight women were split into three groups to test the effects of different types of aerobic exercise on their body mass index. The data was analysed by statisticians, who compared the subjects' cardiorespiratory parameters before and after participating in aerobics for 12 weeks. Aerobic exercise led to a notable increase in vital capacity without affecting the resting heart rate.

Nilsson et al. (2008) conducted studies on group aerobic interval training for those with chronic heart failure. In terms of chronic heart failure (CHF), this case study looked at how four individuals responded to a military rehabilitation programme. Patients numbered 1, 2, and 3 showed the greatest increases in aerobic capacity, at 17 percent, 25 percent, and 52 percent, respectively. Patient 4 did not finish the ergo metre testing because of pacemaker limitations. Patients 1, 2, 3, and 4 all saw increases in their 6MWT distances (117m, 66m, 135m, and 143m, respectively). No adverse consequences were reported. The Norwegian Ullevaal Model for cardiac rehabilitation is distinguished by its emphasis on high-intensity activities with minimal rest intervals. The physical and mental health of four people with chronic hepatitis C (CHF) were demonstrated to improve without any adverse consequences. Congestive heart failure (CHF) patients benefited from HIIT in animal studies.

Sudha (2008) looked at the effects of aerobic exercise on a few physiological markers in young women at a university. Theivannai Ammal College for Women in Villupuram selected 60 female students for this. People in this study ranged in age from 18 to 20. The selected themes were divided into two categories. Aerobic exercise training was given to one group, while the other group served as a control to assess any significant post-test changes after controlling for baseline differences. The data was analysed using analysis of covariance (ANCOVA). Aerobic exercise was found to dramatically increase resting heart rate, breath-holding time, vital capacity, and respiratory rate.

Baker et al. (2010) studied the impact of aerobic exercise on mild cognitive impairment patients' cognitive abilities and other Alzheimer's disease risk factors. Thirty-three participants, ranging in age from 55 to 85, were enrolled in the study because they had amnestic mild cognitive impairment. Engagement Participants were randomly assigned to either a high-intensity aerobic activity group or a stretching control group. Exercise four times a week, every day, for six months at 75-85% of maximal heart rate reserve. The heart rates of those in the control group were maintained at 50% of their maximum during the whole workout. The participants' fat distribution was mapped using dual-energy X-ray absorptiometry, and they also underwent neuro metabolic and treadmill tests before and after the study. Blood was obtained for an assay and cognitive tests were administered at baseline, three months later, and six months later. Exercise training at a higher intensity for six months resulted in particular impacts on the hypothalamic-pituitary axis, trophic activity, and glucose metabolism in men and women, but not on cardiorespiratory fitness or body fat reduction. Aerobic exercise has been demonstrated to improve female performance on a battery of executive function tests, including the metabolic clamp and measures of cortisol, brain-derived neurotrophic factor, and fasting plasma levels of insulin. Males who engaged in cardiovascular exercise saw an increase in their blood level of insulin-like growth factor I, which improved their performance on the Trails B test. This study provides strong evidence that non-pharmacological interventions can improve executive control abilities in older women at high risk of cognitive decline.

Andriolo et al. (2010) found out if people with Down syndrome could benefit from participating in aerobic fitness training programmes. As a starting point, they searched ClinicalTrials.gov and the National Research Register for information on active clinical studies (2009 Issue 1). Aerobic exercises as diverse as walking/jogging and rowing training (for participants aged 17 to 65) were included in the studies that made up this systematic review. Tests were conducted in the US, Portugal, and Israel. Only maximum treadmill grade was shown to be improved after aerobic exercise training (4.26 grades (percent) [95 percent CI 2.06, 6.45]). Other variables (maximum test length, total fan wheel spins, ergometer resistance, power knee extension, and timed up and go test in the intervention group) showed improvements as well, but they were not appropriate for meta-analysis pooling due to their small sample sizes. Thirty additional outcomes were investigated in this study, but only oxidative stress and body composition variables were included in the meta-analysis. In the research, improvement in areas other than productivity did not reach statistical significance. Aerobic exercise may help people with Down syndrome, but the evidence for its positive effects on their health and happiness is mixed. Mixed physical activity programmes have been demonstrated to have favourable effects on physiological and psychological factors, but more rigorous research is needed before educated practise decisions can be made.

Czuba et al. (2011) studied how cyclists' aerobic capacity and endurance performance changed after undergoing intermittent hypoxia training. Twenty-three percent of eligible adults participated in the study. The maximal oxygen uptake (VO2max) was measured in ml/kg/min; the individual weighed 66.7 kg, had a fat-free mass of 59.3 kg, and was 1.78 m tall. In the hypoxic (H) group, the fat content (percentage) was 11.3%, while it was 7.9% in the control (C) group. Throughout the course of the experiment, both groups were given the same instructions. In the H group, members trained under normobaric hypoxia three times weekly for a total of three weeks. One micro cycle of an IHT session lasted 30 minutes, another 35, and the final 40 minutes were spent at 95 percent WRLT intensity. The C group also engaged in this same training schedule, but their major sessions' intensity was adjusted using WRLT normoxia.All measures of maximal aerobic capacity (WRmax, VO2max, WLT, lactate concentration (LA), and VO2LT) increased significantly in the H group during the incremental test. The time trial saw a considerable improvement in average speed and average generated power while also decreasing overall duration. The research (HCT) found that intermittent IHT had no effect on haematological indicators including RBC count, haemoglobin concentration, or hematocrit value. There was a noticeable elevation in blood values only in the H subgroup of subjects. Aerobic capacity and endurance appear to be improved by training for 30-40 minutes at lactate threshold intensity on occasion when under hypoxic conditions.

Obert e.al. (2011) determined if prepubescent children's maximal power (Pmax) produced during a short-term exercise test is affected by an aerobic training programme. There were 33 participants, 17 boys, and 16 girls, ages 10-11, who took part in a 13-week running programme, with each session lasting one hour. The 16 students who were assigned to the control group weren't asked to do anything for the study. Pmax was determined through testing on a friction-loaded cycle ergometer. The optimal force (Fopt) and optimal velocity (Vopt) for achieving Pmax were determined. The LMM was analysed with dual X-ray absorptiometry. Pmax increased regardless of the changes in muscle mass that occur during the maturation period. Since Vopt did not alter as a result of training, the increase in Fopt must have been the primary factor. After training, Fopt was remained greater than before (p 0.01). In addition, the anaerobic test showed no significant changes in CG over the course of the study's time period. The TG and CG did not differ in Pmax and Fopt prior to training. They came to the conclusion that aerobic training in children before puberty raises peak power in explosive, short-duration exercises.

Ghanbari et al. (2013) used a comprehensive review to determine if RMT improves sports performance by strengthening and conditioning the respiratory muscles. The Cochrane Collaboration protocol was adhered to throughout the methodology. Searches were conducted in MEDLINE, CINAHL, SPORTDiscus, PEDro, EMBASE, EBM reviews, and COCHRANE up until July 2011. Articles were included if they fulfilled the following criteria: Studies that (a) used athletes as subjects, (b) used a randomised controlled design to compare RMT to sham or control, and (d) were reported in English are considered to be high-quality studies of RMT's effects on athletes' respiratory muscles and performance. Two authors used PEDro and data abstraction to conduct the quality check. Outcomes included exercise capacity, spirometry, respiratory muscle strength and endurance, and athletic performance. For results reported in two or more research, meta-analyses were carried out. The systematic review found that out of 6,923 citations returned by the search approach, only 21 met the inclusion criteria. Results from exercise endurance tests, Yo-Yo tests, and time trials were among those considerably enhanced by RMT, according to a meta-analysis. Regardless of the type of RMT employed, most studies found that it increased respiratory muscle strength and endurance. Variations in RMT techniques and result indicators among studies also made it difficult to determine which group of athletes would gain the most from RMT. In conclusion, RMT can improve performance in sports. If the respiratory demands of RMT are more closely matched to those required during athletic competition, and if training intensity is increased more aggressively, future study may show even higher improvements.

Earnest et al. (2014) examined The benefits of AER for persons with type 2 diabetes and metabolic syndrome have only been studied in a small number of trials. Individuals with Type 2 diabetes were monitored for nine months while they participated in AER + RES, RES, and AER training according to physical activity standards. Prevalence and metabolic syndrome score modification were the two most important follow-up outcomes. Secondary outcomes were exercise effectiveness, maximum cardiorespiratory fitness (VO2peak), and estimated METs from time-to-exhaustion (TTE). The effects of training on metabolic syndrome were studied using bootstrapped Spearman correlations and general linear models. Significant improvements in metabolic syndrome scores were observed between the AER and AER + RES groups and the control and RES groups. In the AER and AER + RES groups, the incidence of metabolic syndrome decreased between the two time points studied. Time-to-exhaustion was a better predictor of improvement in exercise efficiency than VO2peak for the AER+RES and AER training groups. Patients with type 2 diabetes whose care included AER or AER+RES saw a dramatic reduction in metabolic syndrome scores and prevalence.

Ayudthaya and Kritpet (2015) explored Thai office ladies choose low-impact aerobics like fit ball exercise and dance. Between the ages of 35 and 45, 47 women participated in the study. Both groups had their members wear heart rate monitors during the exercises. The exercises were performed three times weekly for 35 minutes at an intensity of 60% to 80% of the individual's maximum heart rate over the course of 12 weeks. Physiological and physical indices, as well as bone resorption, were measured both before and after the 12-week training programme. We used paired t-tests and other tests to compare and analyse data collected before and after training, as well as data collected on changes to dependent variables. The significance level for this study was set at the 0.05 level. Bone resorption (Cross Laps) was reduced in all three groups compared to the first, although only the first group showed a statistically significant reduction. Bone formation and resorption rates were similarly low in the two groups. After the exercise, both groups saw significant improvements in their maximal oxygen uptake, muscular strength, and resting heart rate, while also seeing significant reductions in their systolic and diastolic blood pressure. Everyone in the group became much more flexible after utilizing the fit ball. Bone resorption can be slowed with the use of low-impact aerobic exercise like dancing or utilising a fit ball. Additionally, they aid in relaxing the muscles of the lower back.

Park et al. (2016) conducted a meta-analysis of controlled trials, researchers compared the effects of altitude training against training at sea level on top Korean athletes in terms of their blood oxygen delivery capacity and aerobic exercise capacity (experimental). Three databases (the National Assembly Library, the Korean studies Information Service, and the Research Information Service System) were used in randomised controlled trials comparing altitude/hypoxic training against training at sea level. To capture heterogeneity and compare altitude/hypoxic training with sea-level training, a random effect model meta-analysis was used to analyse RBC, Hb, Hct, and VO2max in elite athletes. We utilised a fixed effect meta-analysis with EPO as a proxy for consistency. There were a total of 156 elite athletes included in the meta-analysis of eight studies (n = 82 experimental and 74 control). Increases in red blood cell count (4.49910(5) cell/ul, 95% CI: 2.469-6.529), haemoglobin concentration (Hb), hematocrit (Hct), erythropoietin levels (EPO), and maximal oxygen consumption (VO2 max) were observed.

Porcari et al. (2016) examined the effects of elevation training masks on aerobic capacity and haematological variables and their effect on lung function. Respiratory muscle training (RMT) and exposure to high altitude improved the performance of already-highly-skilled athletes. Athletes might gain an edge over their rivals with the help of altitude and RMT equipment. Aerobic capacity (VO2max), endurance, and lung function have all been shown to increase with the help of the Elevation Training Mask 2.0 (ETM). A six-week high-intensity cycle ergometer training programme was completed by twenty-four moderately trained volunteers. Participants were randomly assigned to either the mask (n = 12) or control (n = 12) groups. No major differences were found in pulmonary function or haematological indices within or between the groups. No significant difference in enhancement was observed between the groups. The ETM, when combined with interval training, may lead to gains in specific measures of endurance performance. The one most crucial point to keep in mind Using the ETM for high-intensity cycling training has the potential to improve a variety of performance indicators, including VO2max, PPO, VT, and RCT. Lung capacity, inspiratory muscular strength, and haemoglobin and hematocrit levels were not altered by ETM use.

Biggs et al. (2017) Studies of aerobic exercise at high altitude have shown an increase in the maximum oxygen consumption. Several advances in the study of exercise are indebted to the ability to replicate these effects through simulated altitude training. Few studies have shown that using an Elevation Training Mask (ETM) has the same beneficial effect on cardiorespiratory fitness as working out at a higher altitude. The effects of a hypoxia-inducing mask on cardiorespiratory fitness and pulmonary function were studied using a high intensity interval training (HIIT) running programme in this investigation. Seventeen people were randomly allocated to either a non-mask wearing control group or a mask wearing experimental group, and both groups participated in a 6-week HIIT routine consisting of four sessions per week. Running at 80% of one's heart rate reserve (HRR) for 90 seconds followed by three minutes of active rest at 50% to 60% of HRR was the format of each workout, after a brief warmup. There were six full intervals in each meeting. There was a substantial increase in predicted VO2max among individuals ($F(1,17)=7.376$, P.05). However, there was no significant difference between the experimental and control groups in terms of estimated VO2max ($F(1, 17)=3.669$, $p=.075$). Forced inspiratory vital capacity did not differ significantly between groups ($F(1, 17)= 3.724$, $p =.073$) or between individuals ($F(1, 17)= 3.724$, $p >.05$). Consistent with the elevated VO2max values, patients' forced vital capacity also increased significantly ($F(1, 17)=6.201$, p.05). However, $F(1, 17)=3.562$, $p=.079$ shows that the experimental and control groups did not vary significantly. Even though there was no statistically significant difference between the two groups, all three variables increased more in the ETM-wearing experimental group than in the non-mask-wearing control group.

Warrenn et al. (2017) studied the Influence of an Elevation Training Mask on the Maximal Oxygen Consumption of Male Recruits in the Reserve Officers' Training Corps Male Reserve Officers Training Corps (ROTC) cadets did a study with the purpose of assessing the influence of an elevation training mask (ETM) on their VO2max. In this study, 14 male ROTC cadets (average age 20.001.8 years, height 174.353.1 cm, weight 76.7511.09 kg, body fat 13.884.62%) were tested to see if using an ETM significantly increased VO2max. Following the familiarisation period, test subjects were randomised to be put in the experimental or control groups. Each person engaged in the programme for a total of seven weeks, attending three times per week. Four days after the last training session, a post-test was given. Analysis of the data showed that there was no significant difference in VO2max values between the experimental and control groups ($p = 0.34$). The results of this study showed that the ETM did not significantly increase VO2max when used under the study's training settings.

Kurobe et al. (2017) revealed that acute growth hormone release is greater in hypoxia than in normoxic conditions after exercise. The effects of resistance training on muscle strength, muscle thickness, and hormone responses were investigated in this study. Thirteen healthy males were split into two groups according to their fitness levels and then given instructions to perform aerobic activity in either a normoxic (20•9%) or hypoxic (12•7%) environment. For eight weeks, three times a week, the subject performed three sets of unilateral arm elbow extensions till fatigue, with a maximum of 10 repetitions and a one-minute rest between each session. B-mode ultrasonography was used to compare pre- and post-exercise triceps brachii and biceps thickness. Before and after each workout, as well as at the beginning and end of the programme, blood samples were taken. The triceps brachii of the exercised arm thickened more in the hypoxia group than in the normoxia group. Maximum number of sets of 10 reps increased significantly in both the trained and untrained arms across all groups. Serum growth hormone concentrations were significantly higher in the hypoxic group than in the normoxic group after both the first and last workouts.

Akazawa (2018) revealed that acute growth hormone release is greater in hypoxia than in normoxic conditions after exercise. The effects of resistance training on muscle strength, muscle thickness, and hormone responses were investigated in this study. Thirteen healthy males were split into two groups according to their fitness levels and then given instructions to perform aerobic activity in either a normoxic (20•9%) or hypoxic (12•7%) environment. For eight weeks, three times a week, the subject performed three sets of unilateral arm elbow extensions till fatigue, with a maximum of 10 repetitions and a one-minute rest between each session. B-mode ultrasonography was used to compare pre- and post-exercise triceps brachii and biceps thickness. Before and after each workout, as well as at the beginning and end of the programme, blood samples were taken. The triceps brachii of the exercised arm thickened more in the hypoxia group than in the normoxia group. Maximum number of sets of 10 reps increased significantly in both the trained and untrained arms across all groups. Serum growth hormone concentrations were significantly higher in the hypoxic group than in the normoxic group after both the first and last workouts.

Jung et al. (2020) examined how the ETM affected the heart rate variability (HRV) and hemodynamics in healthy individuals during rest, exercise, and recovery in the short term.

The 40-minute cycling workout program was broken down into four 10-minute segments: (1) rest; (2) cycling at 50% of VO2peak; (3) cycling at 70% of VO2peak; and (4) recovery. Systolic blood pressure increased more (p=.035) whereas SPO2 decreased (p=.033) during high-intensity cycling in the MASK trial. When riding, there was no difference in the HRV indices between trials. Nevertheless, after recovery, heart rate (p=.047) was higher in the MASK trials compared to the CON trials, but inter-beat interval and sympathovagal balance were lower. Cycling at a moderate exertion (70% of VO2peak) while wearing an ETM result in mild hypoxemia. While the HRV alterations during cycling were unaffected by this device, it seems to slow down the recovery of the cardiac-autonomic system after exercise.

Mohamed et al. (2021) assessed the effects of HIIT on VO2max and HRV in trained athletes. The HRV features that have been examined are the mean R-Rms interval duration, the High-frequency peak (HF Peak), and the Low-frequency peak (LF Peak). This study recruited 12 male soccer players from the University of Mansoura because of their high levels of physical exercise. Both MG and CG engaged in HIIT three times per week for a total of eight weeks. Four days after the final class, an evaluation was given to see how much was retained. There were statistically significant (p0.05) changes in VO2max measured before and after treatment for both the MG and CG groups. There were statistically significant differences between the pre- and post-test readings of VO2max (p0.05), HR rest (p0.05), HRV Mean RR (p0.05), and LF Peak (p0.05) for the MG group. There were statistically significant differences in VO2max (p0.05), HR rest (p0.05), and HRV Mean RR (p0.05) for the Mask group. Enhanced VO2max, HRR, HRV, and and LF Peak were observed in the current study's training conditions as compared to the CG.

Smith et al. (2022) conducted after four weeks of hypoxic high-intensity interval training, the basketball players' anaerobic and aerobic capacities were tested. Fifteen female basketball players participated in a randomised controlled trial where they were split into groups that trained in normobaric hypoxia or normoxia for eight, one-hour sessions. The normoxic group gained 0.2% to 2.3%, while the hypoxic group gained 2.5% to 2.3%; this difference was clinically significant but statistically insignificant. There was no statistically significant difference in the mean interval recovery distance between the hypoxia and normoxia groups. When compared to the normoxic group, those in the hypoxic group reported higher levels of stress, fatigue, and musculoskeletal discomfort. While high-intensity interval training (HIIT) in hypoxic settings improved the performance of female basketball players in a 1-minute all-out shuttle run, it also increased the players' subjective indications of stress and tiredness.

Jagim et al.(2012) investigated the impact of the elevation training mask on the strength performance of recreational weightlifters. Acute effects of the ETM on mental fatigue, metabolic stress indicators, and resistance exercise performance were investigated. Twenty male recreational weight lifters underwent two training sessions consisting of back squats and bench presses (6 sets of 10 reps at 85% of 5-repetition maximum and seventh set to failure) and a maximal effort sprint test (18% body mass) with the mask (ETM) and without the mask (NM). The evaluation of training included taking readings of blood lactate and oxygen saturation both before and after exercise. The evaluation took into account the athlete's maximum and average bar velocity as well as their volume, intensity, reps, and sprint times. Dizziness, anxiety, and pain were among the negative side effects reported by 12% ($n = 3$) of the participants. There were no significant differences in total work or reps performed between the conditions in the back squat ($p = 0.07$) or the bench press ($p = 0.08$). Peak velocity was lower in the ETM condition across all three tests (sprint, bench press, and squat) ($p = 0.04$). During the ETM condition, blood lactate levels were lowered following a sprint and bench press ($p < 0.001$)..

Studies related to anaerobic training

Ziemann et al. (2011) studied since little information exists on this ratio, high-intensity interval training at a 1:2 work-rest ratio is being used to ascertain the benefits to aerobic and anaerobic metabolism. Two groups of physically active male volunteers (age 21, height 184 cm, weight 81.5 kg) were recruited at random and placed into the interval training (IT; n = 10) and control (n =) conditions. The first assessments were repeated at the conclusion of the training. The interval training programme consisted of six to ninety second bursts of cycling at eighty percent of VO2max, three times a week for six weeks. During the entire six weeks, the control group didn't change their daily habits. In-group assessments taken repeatedly Results from an analysis of variance showed that IT had a statistically significant effect on increasing VO2max, max power, glycolytic work, anaerobic threshold, mean power, peak power, and work output. The average rating for IT in Los Angeles dropped in the first five minutes, but then skyrocketed after the next fifteen. Recreational college-aged males' markers of aerobic and anaerobic performance were significantly enhanced after six weeks of cycling for 27 minutes at 80% of one's p VO2max, spread across three sessions per week.

Chtourou H et.al. (2012) investigated the effects of time of day and Ramadan-intermittent fasting (RIF) on physical strength and fatigue while doing the Wingate test. Ten professional NFL football players were given the Wingate test three times. Any two successful tests must be separated by at least 36 hours. The Wingate test was used to precisely evaluate the athlete's fatigue index (FI) and other measures. In contrast to BR, when PP and MP are larger in the evening, diurnal variations in muscle power are smaller during Ramadan due to a significant drop in PP and MP at night. At 17:00 h, the diurnal variation in FI grew considerably.

Bonato et.al. (2015) looked at the effects aerobic training could have on the heart rate and oxygen consumption of top judo athletes. Aerobic training for the selected judokas consisted of two 30-minute runs at 60% of Vmax and one high-intensity interval training session at 90% of Vmax with active recovery at 60% of Vmax over the course of 12 weeks.Before and after the treatment, the subjects had a graded maximal exercise test to measure their VO2max, VT, maximal velocity, heart rate, and V O2 off kinetics. The kinetics of VO2 and HR recovery were examined breath by breath using an exponential function with a single component. Anaerobic capacity during selected judo techniques was evaluated using the Special Judo Fitness Test. Although there was no change in V O2max, maximum aerobic power increased significantly. The HR and V O2 recoveries dropped by 17.3% and 22.0%, respectively. There was a twelve percent increase in VT and SJFT Index scores after the training

Krings et.al. (2016) examine the effects of rapid carbohydrate ingestion on anaerobic exercise performance. The subjects (n = 7) took part in a series of activities while consuming either an amino acid electrolyte control (CON) or a CON with varying concentrations of CHO. The CHO beverages included either 15g/h, 30g/h, or 60g/h of glucose to fructose, respectively. The training routine also included shuttle sprints and jumps. Sprinting times, two-foot line jump times, and 137-meter sprint times were all tested to exhaustion. Total repetitions were also tallied for all sets performed to failure and for all sets performed on the two-foot line in a certain amount of time. A significant main effect (p 0.05) was found for the number of bench press repetitions performed in the last set to failure in relation to the CHO dose. When comparing the 15 g/h and CON groups during bench presses, a pairwise analysis using Bonferroni's correction showed a statistically significant difference ($p = 0.0024$). When compared to 60 g/h and CON, total RT performance was shown to be 99.2 percent (very likely) and 96.7 percent (very likely) to have a beneficial influence. This study's findings suggest that consuming carbohydrates (CHO) does not hinder performance and may even improve strength and conditioning.

Frikha et.al. (2016) assessed the effect of varying AWU durations and the rest period between them on anaerobic performance. Eleven male 22.6-year-olds with an average height and weight of 1.79 metres and 82.5 kilogrammes participated in a cross-over randomised study in which they took the Wingate test after 5, 15, and 20 minutes of anaerobic work-out (AWU), with and without a rest period (WREC and NREC), respectively. All of them were completed at 60 rpm, or at 50% of the participants' maximum aerobic capacity. Following the conclusion of the warmup, a mandatory five-minute break was instituted. The mouth's temperature was taken while the subject was getting comfortable. In addition to recording RPE and HR, we also recorded HR before and after the Wingate test. Recovery time, warm-up duration, and assessment site were significantly (P0.05) correlated with evaluations of perceived exertion. The investigation found that the recovery interval significantly affected the duration of the AWU (P0.001 for MP and PP, respectively).

Czuba et.al. (2017) examined how IHT affected swimming performance and aerobic and anaerobic capacity in elite swimmers. A total of 16 male swimmers participated in the hypoxia (H) group study, with 8 groups training in normobaric hypoxia and 8 groups performing exercises under normoxic conditions. But one guy walked out of the research without explanation. Group H swam in normoxic conditions but exercised twice weekly on land under hypoxic conditions. During the same workout, Group C had normal oxygen levels. The four weekly micro cycles of training resumed for the trainees after a respite period of three days. At the beginning of each land practise session, athletes would complete a 30-second sprint on an arm ergometer, followed by a 2-minute high intensity period on a lower limb bike ergometer. The data demonstrated that training on land enhanced WRmax by 7.4 percent in group H and 3.2 percent in group C, as well as VO2max relative values by 6.9 percent in group H and 3.7 percent in group C, considerably. However, there was not a great deal of variation in the absolute VO2max levels. Only in group H was there a statistically significant increase in mean power of 11.7% and 11.9% for the first and second Wingate tests, respectively. Lactic acid levels were 28.8% greater than pre-Wingate levels in group H following both Wingate sessions. Group H showed a statistically significant 33.3% fall in blood pH (pH) delta values after both Wingate tests. The IHT prompted significant gains in both the 100 and 200 metre swimming times of Group H (2.1% and 1.8%, respectively). Normal oxygen levels (group C) improved swimmers' times in the 100 and 200 metres by 1.1% and 0.8%, respectively. The most remarkable outcome of this study was the considerable enhancement of anaerobic capacity and swimming ability after high-intensity IHT. This training programme had no effect on VO2max or haematological variables.

2.2 Studies on both aerobic and anaerobic training

Morton and Cable (2005) Analyse how training in intermittent hypoxia affects your aerobic and anaerobic capacities. Eight athletes with a moderate amount of training for team sports cycled for 30 minutes, three times a week, for four weeks. One group was taught at an artificially-created altitude of 2750 m, while the other was schooled in a laboratory at sea level. In the incremental exercise test, performed at sea level, participants alternated between one-minute bursts of 80 percent maximum exertion sustained for two minutes (Wmax) and two-minute bursts of active recovery at 50 percent Wmax. A 5-percent increase in training intensity was attained after six training sessions and another 5-percent increase after nine training sessions. On a cycle ergometer at sea level, we measured VO2max, power output at the start of 4 mM blood lactate accumulation (OBLA), Wmax, and anaerobic Wingate performance before and after training. VO2max, Wmax, OBL, and OBLA all increased significantly in the hypoxic group, as did mean power, peak power, and mean power in the normoxic group. Both types of training environments resulted in comparable gains across all of the aforementioned performance indicators. Between the two groups, there were no statistically significant changes in either haemoglobin concentration or haemoglobin sufficiency ($p > 0.05$).

Baumann and Wetter (2010) looked at how collegiate men's distance runners' aerobic and anaerobic fitness changed over the course of a season. Eight male distance runners were subjected to a battery of aerobic and anaerobic laboratory tests at the beginning and end of an 8-10 week racing season. Aerobic testing (OBLA) included assessments of VO2max, RE, VT, lactate threshold, and the onset of blood lactate accumulation. Anaerobic performance was evaluated with the Wingate test and the vertical jump (VJ). While there were no significant changes in VJ or other aerobic measures ($P > 0.05$), anaerobic Wingate peak power declined significantly from the initial testing (11.81.1 to 10.71.0 Wkg-1) (P = 0.006).

Zagatto et.al. (2011) conducted maximum anaerobic running test and the relationship between anaerobic contribution and accumulated oxygen deficit. Both investigations aimed to determine if there was a correlation between the MAOD and MART, which is the maximum cumulative oxygen deficiency. Eleven servicemen were sent in to help with the probe. Participants used a treadmill to do MAOD and MART. The most severe hypoxia resulted during alternating periods of effort and rest lasting 20 and 100 seconds. Oxygen uptake, lactate response measures, and oxygen utilisation after exercise were also used to test MART's ability to isolate the role of the energy system. In order to determine the maximum oxygen consumption (MAOD), five submaximal and one supramaximal workouts were performed. The anaerobic system delivered 73.51.0% only during the exertion phases, whereas the aerobic energy system supplied 65.4%1.1% over the entire test, the anaerobic a-lactic system contributed 29.5%1.1%, and the anaerobic lactic system gave 5.10.5%. Maximum output in MART was 111.251.33 mL/kg/min, however it was unrelated to MAOD in any meaningful way. The anaerobic a-lactic pathway is crucial to MART efforts, but this analysis found no link to MAOD.

Rodriguez (2014) discovered the effects of aerobic and anaerobic exercise on eating disorders. Using reliable assessments like the EAT-26 and Primed, W E evaluated 206 males who had completed training. Aerobic exercisers showed higher values on the majority of the EAT-26 measures and in the overall score. The trainees in this group saw improvements in their Oral Control as they increased the frequency and duration of their exercise. Supplement users are more prone to struggle with an eating disorder. Eating disorder predisposition and scores on the EAT-26 are also boosted by high-structured training sessions. Athletes appear to be at a greater risk for TCA due to their high rates of aerobic exercise.

Mazurek et al. (2014) examined College women's blood cholesterol, muscle mass, and aerobic capacity were measured before and after participating in either a continuous moderate exercise programme or an aerobic interval training programme.Three groups of individuals were randomly assigned to take part in organised physical activity (OPA) three times weekly for 47-minute sessions. They split up into three distinct teams. The first group did two sets of 6-by-10-second sprints at 65-75 percent of their maximum heart rate while pedalling at top speed. Before and after OPA anthropometry, the subjects' anaerobic and anaerobic capacities and lipid profile indices were measured. AIT resulted in a much larger decrease in waist circumference, WHR, and total skinfolds compared to CON and CME. After treatment, AIT saw far larger increases in both relative and absolute VO2max than CON. Anaerobic test results, including work production and peak power output, improved significantly across the board with AIT, CME, and CON. There were no interactions between training type and the efficacy of OPA; triglyceride concentrations were lowered only in the CON and CME groups.

Foster et al. (2015) study that, after eight weeks of training, compared the aerobic and anaerobic capacity of two HIIT regimens to a control group. Fifty-five first-time students were split into three groups and trained three times weekly over the course of three weeks. Twenty minutes of cycling at 90% of the ventilatory threshold (VT) were completed on an ergometer. To achieve a VO2max of 170 percent, we employed Tabata's eight 20-second intervals with a 10-second rest period in between. Each participant underwent 24 training sessions over the course of eight weeks. Peak and mean power both increased by 8% during Wingate testing, while VO2max and PPO both increased by 17% during Wingate testing; all of these improvements were statistically significant at the $p = 0.05$ level. However, there were no statistically significant differences between the groups on any of these measures. Results reveal that among sedentary teenagers and young adults, HIIT therapies do not outperform more conventional types of exercise despite the time savings. The one most crucial point to keep in mind Students with no prior training receive "steady-state" instruction, which is equivalent to HIIT. Due to the greater physiological demand, high-intensity interval training (specifically extremely high-intensity variants) was rated as less enjoyable than steady-state or low-interval training.

Lukacs and Barkai (2015) compared the effects of anaerobic and aerobic exercise on the blood sugar management in children with type 1 diabetes. The level of glycemic control was evaluated using HbA1c. HbA1c evaluations before and after an intervention of at least 12 weeks' duration were required for the study to be declared valid. There were nine papers uncovered between those years. However, one study included 401 young people with diabetes (166 males and 235 females), with an age range of 13-30 years old. Taiwanese, Brazilian, Lithuanian, Australian, Egyptian, Turkish, Belgian, Tunisian, and French people were just some of the participants. One study compared aerobic and anaerobic exercise, while four studies looked solely at aerobic activity. None of the reviewed trials adequately demonstrated that any form of exercise or mix of training improved glycemic control in children with type 1 diabetes. Only three studies (two aerobic and one combined) showed any significant improvement in glycemic control.

Gharbi et al. (2015) examined the impact of aerobic and anaerobic parameters on the repeated sprint performance of team sports athletes. Sixteen sportsmen from various sports took part in the research. They ranged in age from 23.4 down to 2.3 years, in height from 178 to 7 centimetres, and in weight from 71.2 to 8.3 kilos. Eight people were approved for the football licence, five for the basketball licence and three for the handball licence. A multi-stage shuttle run of 20 metres, a sprint of 15 metres, and a 180-degree sprint of 15 metres were all part of the MSRT, WingT, MASRT, and RSA. They completed a 30-second WingT and a 60-second MASRT. Pearson's product-moment correlation was used to determine the level of association between the various physical assessments. There were no significant correlations discovered between the RSA test indices and WingT. The MASRT, the fatigue index (FI), and the total sprint time (TT) of the RSA all had negative relationships with one another. Maximum VO2max was found to be inversely linked with both peak sprint time (PT) and total sprint time (TT). A substantial association was seen between VO2max and RSA FI, nevertheless.

Gillen and Wyatt (2016) concentrated on the experiment's anaerobic and aerobic efficiency. Eleven willing participants were found for this study. Many respondents expressed interest in both endurance and resistance training. According to ACSM standards, participants needed a VO2max of at least 80% to be considered trained. The results show that there is a significant correlation between Vo2max and RFD ($r = 0.68$). To dig deeper, we used Cohen's effect size to find that power endurance, relative peak power, peak power, and running efficiency all had strong associations with VO2max. These results suggest a possible positive link between anaerobic performance measures like RFD and aerobic performance measures like VO2max.

Saghiv et al. (2017) looked studied the effects of aerobic and anaerobic exercise on the levels of soluble Klotho and IGF-I in the blood of young, healthy persons, old, and patients with coronary artery disease (CAD). It has been proven that long-term aerobic exercise training affects the levels of insulin-like growth factor 1 (IGF-1) and soluble-Klotho (s-Klotho) in the blood (IGF-I). The use of klotho has the potential to increase longevity, improve general health, and mitigate the debilitating effects of ageing on bodily functions.

The latest findings in this field of study are summarised below. Those with and without coronary artery disease, as well as younger adults, are analysed to see how different types of dynamic exercise alter their blood levels of IGF-1 and s-Klotho. W ith these findings in mind, it appears that long-term (chronic) aerobic exercise training is likely to be one of the antiaging variables that aid in slowing or reversing the process that leads to ageing and cardiovascular disease. However, the opposite is true with anaerobic activities.

Hassannejad et al. (2017) studied patients with a BMI were evaluated for the effects of aerobic or aerobic-strength exercise on body composition and functional performance. Body composition and functional capacity were measured before and after a 12-week thyroidectomy in 60 morbidly obese individuals (BMI 35). To determine aerobic capacity, a 12-minute walk-run test was employed (12MWRT). The strength of the muscles in the arms was measured by performing a one-repetition maximum (1RM) test. The patient's lower limb function was measured using a sit-to-stand test. Increases in weight loss, percentage of body fat lost, and fat mass lost were all greater in the trial groups than in the C group. The AS group experienced the least reduction in lean body mass of the three. The intervention groups' mean changes on the 12MWRT increased significantly. There was no statistically significant difference in the mean improvement in sit-to-stand ratings between the three groups. Comparison of the two groups' mean changes in 1RM variables showed a statistically significant split (P = 0.03).

2.3 Studies on intermittent hypoxic training

Truijens et al. (2002) compared the effects of sea-level training with those of training at a higher altitude (hypoxia) or at a lower altitude (normoxia). Over the course of five weeks, a group of competitive college and master swimmers trained with three high-intensity flume sessions and two additional low- to moderate-intensity pool sessions per week. All swimming practise took place under standard conditions. Time trials in the 100 and 400 metre freestyle events were used as benchmarks. The laboratory measured swimming efficiency, anaerobic capacity, and maximum oxygen intake. Performance on the 100- and 400-m trials improved, with the former showing a 1.2 percent drop-in time and the latter a 1.1 percent drop-in time. Here, we're talking about the 400-meter IM. There was no statistically significant difference between the groups at either distance (ANOVA interaction, P = 0.91 for 100-m trials and P = 0.36 for 400-m trials). Enhancements to VO2 max. There was no statistically significant difference in outcomes between the groups (P =

0.58). We discovered that well-trained swimmers' sea-level swimming performances and VO2 max improved dramatically after 5 weeks of rigorous training in a flume, but that hypoxic training had no further advantage.

Roles et al. (2007) find out whether cycling performance in athletes may be improved with a brief burst of intermittent hypoxic training (IHT). Participants were randomly assigned to either the normoxic training (NT, n = 9) or the intermittent hypoxic training (IHT, n = 9) groups. Workout schedule of five weekly sessions lasting an hour to an hour and a half is complete. Training sessions were held at an artificial altitude of 3,000 metres for both the NT and IHT groups. Average power output (V O2 max/Paver) was determined by completing a 10-minute cycle time trial in normoxia (TT) and an incremental fatigue test in normoxia and hypoxia (W0 and W4). Before and after training, there was no discernible difference in V O2 max across the groups. The PPO increased by 7.2% and 6.6%, respectively, in the IHT and NT groups, when measured in normoxia. During hypoxia, only the IHT group displayed a notable improvement in PPO. In the NT group, the TT Paver increased by 8.1%, whereas there was no significant change in the IHT group. Training under hypoxia was not as effective as exercising in sea level air for increasing endurance.

Hamlin et al. (2010) tested whether or not the "live low, train high" approach improved endurance and/or anaerobic cycling performance. The Wingate test consisted of 16 highly trained athletes completing 90 minutes of endurance training per day for 10 days. Intermittent hypoxic training (IHT) was found to be more effective than placebo training at raising arterial blood oxygen saturation (FIO2 = 0.21). A baseline and familiarisation test were conducted at sea level, followed by two more examinations at two- and nine days post-intervention. The 30-second Wingate test's mean power was 3.0% higher than the placebo group's on days 2 and 9 after IHT. It appeared that other measures of performance were unaffected by the changes. Blood lactate, respiratory exchange ratio, and SpO2 values were all significantly higher in the IHT group two days after the intervention compared to the placebo group. When integrated into their normal training, IHT helped highly trained athletes significantly improve their 30 s sprint times.

Holliss et al. (2013) found Intermittent hypoxic training (IHT) is a method used by athletes to enhance physiological responses to simulated altitude that are independent of haemoglobin levels. Muscle energetics and exercise tolerance (INT) were compared between those who had IHT and those who underwent work-matched intermittent normoxic training. Extensive, single-leg kneeextensor exercise training was done by nine physically active males over three weeks a 25-minute IHT with the experimental leg and a 25-minute INT with the opposite limb served to act as control during each training session. Before and after training, subjects were put through a submaximal session of steady-state activity, a short burst of high-intensity exercise, and an incremental test until exhaustion. There were normoxic and hypoxic phases of testing throughout both the INT and IHT phases.Muscle metabolism was noninvasively measured using a 31P-magnetic resonance spectrometer. Gains in time-to-exhaustion from incremental exercise training under hypoxia and normoxia were not statistically different. It was revealed that in hypoxia, post-IHT, [PCr]- was marginally but much faster compared to post-INT in [PCr]- concentrations during exercise were not statistically significant. The results of this investigation showed that IHT had no discernible effect on muscle metabolic responses or exercise performance when compared to INT.

Campo et al. (2015) assessed how changes in haematological and aerobic performance markers occurred throughout the course of 7 weeks of IHT. Eighteen trained male triathletes were randomly assigned to either the normoxic training group (IHTG) or the control group (CG; both groups were trained in the same way) for the duration of the study. IHT involved weekly 60-minute sessions at a FiO2 level of 14.5–15%, which is above the anaerobic threshold. Before and after the 7-week exercise, aerobic performance and haematological markers were measured. There was a notable difference in the post-workout haemoglobin and erythrocyte levels between the IHTG and the CG. There were no noticeable variations in either group's physiological state or overall performance. Haematological indicators improved after training in normoxia, although aerobic performance and physiological variables were unaffected by IHT training.

Czuba et al. (2017) examined the effects of intermittent hypoxic training (IHT) on swimmers' anaerobic and aerobic capacity as well as swimming performance. Sixteen male swimmers were split into two groups: one trained in normobaric hypoxia (H group) and the other trained in normal air conditions (C group). Group H exercised on land twice a week under simulated hypoxia throughout the experiment; yet, they practised swimming in normoxic circumstances. Group C did the same exercises but with fresh air instead of oxygen. The training schedule consisted of four weekly micro cycles of exercise followed by three days of rest and recovery. During land-based training, swimmers often did two-minute ergometer intervals followed by 30-second arm-ergometer sprints. Data showed that during group H's land-based training, both the absolute maximum workload and the relative values of VO2max increased by 7.4 percentage points and 6.9 percentage points, respectively.There was a statistically significant rise in these numbers. However, there was not much of an increase in the absolute values of VO2max. After the two Wingate tests, the delta values of lactate concentration (LA) in group H were 28.8% higher than the baseline values, which was a significant difference. Group H saw significant increases in swimming performance after undergoing the IHT, with times for the 100 and 200 metre races increasing by 2.1% and 1.8%, respectively. Swimming times for both the 100 and 200 metres were improved by 1.1% and 0.8%, respectively, after training in normoxia (group C).

Sanchez et al. (2018) found that IHT under severe hypoxia with subsequent adaptation to room air has been shown to have negative effects on aerobic and anaerobic capacity at sea level. Fifteen seasoned endurance athletes trained for six weeks on a treadmill, three times per week, at 80-85% of their maximum aerobic speed ().Six athletes trained in room air, whereas nine in the normoxic group (NG) worked out at an oxygen concentration of 10.6-11.4 percent. In comparison to NG, HG significantly lengthened the time it took to become fatigued while running at a speed equal to 95%. No significant differences between training groups were seen. In terms of the decline in leaping ability throughout the course of a 45-second continuous maximum vertical leap test, HG tended to have lower anaerobic capacity indices than NG. Haematological factors including erythropoietin and hematocrit were not significantly different between HG and NG.

Ambrozy et al. (2020) examined the effects of IHT on the anaerobic and aerobic fitness of top national boxers.The research lasted for a total of six weeks. 30 national champion boxers were divided into two groups for the experiment: one was utilised as a control, and the other as an experimental group. Each group trained twice daily, with the same boxing drills. Both the control and experimental groups exercised in the afternoon, but in hypobaric rooms under normal atmospheric pressure. Participants in both groups had their basic anthropometric indices and anaerobic and aerobic fitness measured before and after the 6-week programme. Peak and average anaerobic power, total work, fatigue index, and time to peak power all rose noticeably. The persons assigned to the control group did not experience these shifts. Peak oxygen consumption was not affected by IHT, and neither group showed notable changes in endurance performance.

Smith et al. (2022) tested basketball players' anaerobic and aerobic abilities after four weeks of HIIT in hypoxia. Fifteen female basketball players participated in a randomised controlled study in which they were randomly assigned to normobaric hypoxia or normoxia for eight, one-hour periods of intense training. The normoxic group gained 0.2% to 2.3%, while the hypoxic group gained 2.5% to 2.3%; this difference was clinically significant but statistically insignificant. There was no statistically significant difference between the hypoxia and normoxia groups in terms of the interval at which recovery distance increased. The hypoxic group showed higher levels of stress, fatigue, and musculoskeletal pain as compared to the normoxic group. While high-intensity interval training (HIIT) in hypoxic settings improved the performance of female basketball players in a 1-minute all-out shuttle run, it also increased the players' subjective indications of stress and tiredness.

SUMMARY OF THIS REVIEW OF LITERATURE

A new gadget called the Elevation Training Mask promises to improve multiple facets of sports performance and replicate altitude training. Several studies have been conducted to investigate its effects on different aspects of exercise and training. Here is a summary report of the main findings from various studies on the Elevation Training Mask:

Endurance Performance: Some studies have suggested that wearing the Elevation Training Mask during high-intensity exercise may improve specific markers of endurance performance, such as ventilatory threshold and power output at ventilatory threshold. This improvement is thought to be related to its effects on respiratory muscle training rather than true altitude simulation.

Aerobic Capacity (VO2max): Research indicates that using the ETM during training may lead to a slight increase in VO2max, indicating a potential benefit in aerobic fitness. However, the magnitude of improvement has not consistently shown statistical significance when compared to control groups.

Hematological and Pulmonary Variables: Some studies did not find significant changes in hematological variables or lung function after using the ETM,

Overall, the evidence regarding the efficacy and true simulation of altitude training with the Elevation Training Mask is mixed. While some studies suggest potential benefits in specific aspects of endurance and aerobic performance, others have shown minimal or inconclusive effects.

CHAPTER III

METHODOLOGY

CHAPTER III
METHODOLOGY

This chapter describes the methods used for the selection of variables, subjects, test administrators, training plans, tester and instrument reliability, data reliability, and statistical methods for data analysis.

SELECTION OF SUBJECTS

The subjects of the present study were trainees from Beraboni Block Sports Academy, Paschim Barddhaman, West Bengal. Age range of thirty physically fit individuals was between 18 to 22 years. The selected subjects were randomly divided into three groups of 10 subjects in each group. Group one acted as experimental group A (with mask), group two acted as experimental group B (without mask) and group C was control group.

SELECTION OF VARIABLES

After reviewing various scientific literatures from books, journals, periodicals, research papers pertaining to the hypoxic training, the following physiological and Hematological variables were selected to observe the effect of Intermittent Hypoxic Training.

INDEPENDENT VARIABLE:

- Intermittent Hypoxic Training.

DEPENDENT VARIABLES:

- VO_2 max
- Hemoglobin (HGB)
- MCH
- Red Blood Corpuscles (RBC)
- Fatigue Index
- Blood-Oxygen Saturation Level
- Max Pulse Rate
- Resting Pulse Rate

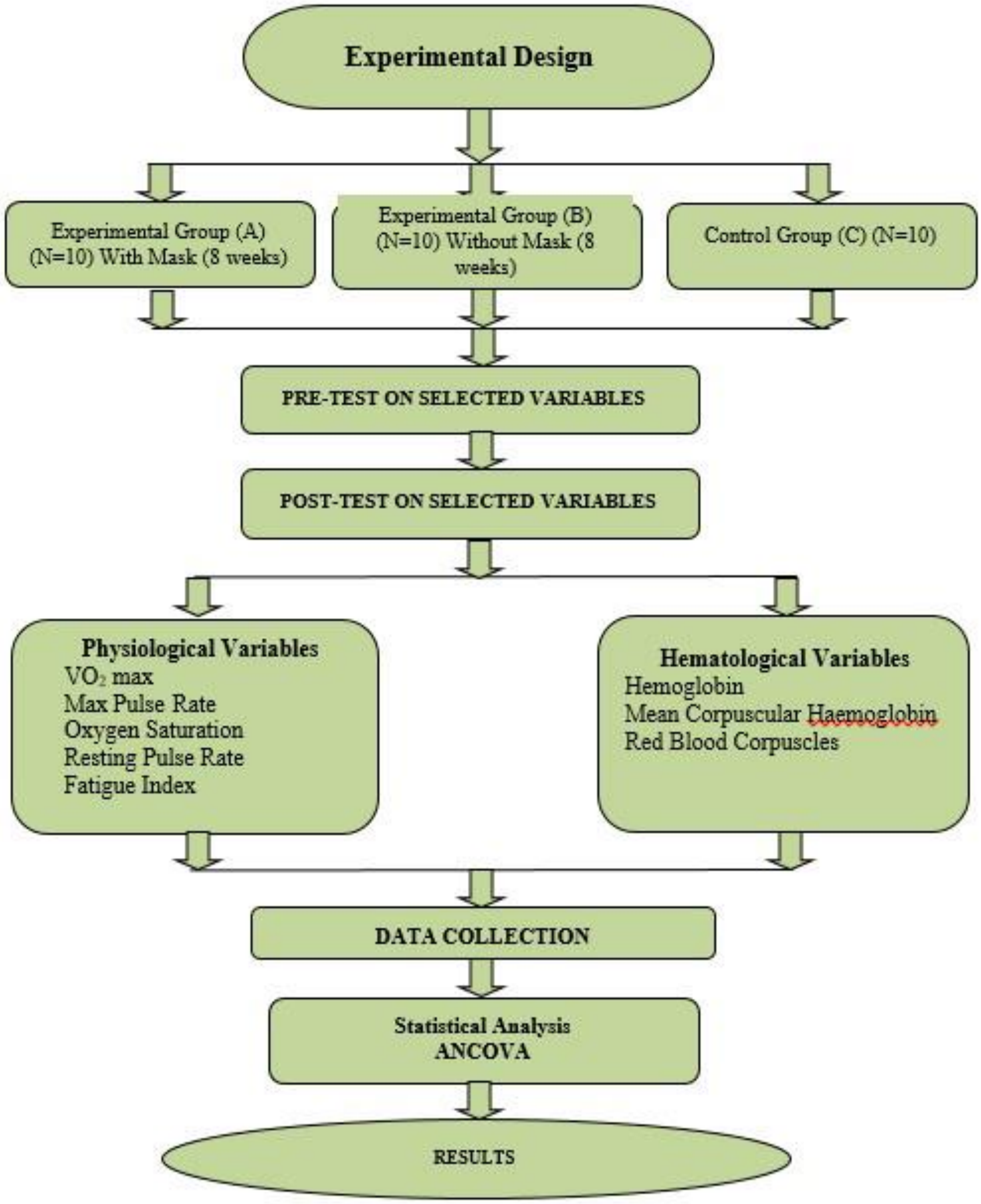

Figure 3 flowchart showing the methodology adopted in the study

SELECTION OF TESTS

The goal of the current investigation was to determine how certain physiological factors affecting anaerobic and aerobic performance were affected by intermittent hypoxia training. The following standardized tests and procedures were employed in accordance with the literature that was accessible in order to evaluate the dependent variables that were chosen and listed in Table 1.

TABLE-1

S.No	Variables		Test/Instruments	Unit of Measurement
1	**Physiological**	VO_2 max	Cooper's 12 Minutes Run/Walk Test	ml/kg/min
2		Max Pulse Rate	Pulse count	Beats/min
3		Blood-Oxygen Saturation Level	pulse "oximetry"	Percentage (%)
4		Resting Pulse Rate	Pulse count	beats/min
5		Fatigue Index	Repeated Sprint Ability test	M
6	**Hematological**	Hemoglobin (HGB)	**Sysmex XP-100 Automatic hematology analyzer** **(**Sysmex corporation , Kobe, Japan) *Code No. BB556095* *Manufactured : July 2012* *Software version: 00-05 and onwards* - Khode V et al. (2012) - Barsam SJ et al. (2011) - Eguchi A et al. (2010) - Ranjith MP et al. (2009) Analytical principle: - WBC: DC detection method - RBC/PLT: DC detection method - HGB: Non-cyanide hemoglobin analysis method	g/dL
7		Mean Corpuscular Haemoglobin (MCH)		Pg/dL
8		Red Blood Corpuscles (RBC)		x10^{6} /µL

ADMINISTRATION OF THE TESTS

PHYSIOLOGICAL VARIABLES

❖ **VO2 Max** (Cooper, 1968)

Purpose - To measure the volume of maximum oxygen uptake (VO2 max).

Test- Cooper's 12 minutes run/walk test

Equipments- 400 meters track, stopwatch, whistle, score sheets and pencils.

Procedure-

A 400-meter track with markings every tenth of a meter was set up for this test. The lap scores were determined by the investigator and the tests. The individuals were instructed to cover as much ground as possible by running or walking after being asked to stand on the beginning line drawn at the 400-meter finish line. They were told to keep running/walking until the last whistle. A whistle was used to start the race and to announce its conclusion after twelve minutes. The alarm went off. Every minute, the subjects were informed of how many minutes remained. When the whistle blew at the twelfth minute, the subjects immediately stopped and stood where they were. To the closest tenth meter, the total distance traveled by each in a twelve-minute period was recorded.

Scoring -

With the aid of the lap scores, each subject's distance traveled was measured in meters. Following the completion of each subject's Cooper test VO2 Max calculator software download, the researcher opens the Cooper test results on his PC. The investigator entered each score one at a time into the appropriate box in accordance with the software's instructions (Total distance traversed was [] meters). Once the score program has been used, the estimated VO2 Max (which is [mls/kg/min]) will be displayed in the result box.

Formula calculated: [(Meters covered - 504.9) ÷ 44.73] (Cooper,1968)

The program was obtained from: http://www.brianmac.co.uk/gentest.htm

Picture 1: Picture of VO_2 Max testing

❖ Max Pulse Rate (Astrand et al., 1990)

Purpose- to Asses maximum Pulse rate

Required Equipment: stopwatch

Administration of the test

Once the 12-minute run and walk test was finished, the maximum pulse rates of each participant were noted. By pressing the fingertips against the carotid artery in the neck, the pulse rate was determined. The total number of pulses counted during the course of a minute was then recorded by the investigator.

❖ Blood Oxygen Saturation Level-(Bhat et al., 2022)

Purpose- To measure the blood oxygen saturation level.

Equipment - Pulse Oximeter

Procedure- A pulse "oximetry" device is a non-invasive way to test arterial oxygen saturation level, and it can be used to assess oxygen saturation.

Scoring - The oxygen content expressed as a percentage (%)

Picture 2: Blood Oxygen Saturation testing

❖ **Resting Pulse Rate** (Han et al., 2021)

Purpose - To determine the resting heart rate (HR) of the subjects.

Equipment - Stop watch (1/100 of a second) and score sheet.

Procedure - The subject was asked to sit and rest comfortably on a chair for 5 minutes. The pulse rate was determined at a radial artery (the frequency of pulse waves per minute propagated along the peripheral arteries is usually identical to HR). The investigator lightly pressed the index and middle finger against the radial artery in the groove on the lateral wrist. The pulse rate was counted for 30 seconds and multiplied by two to get the one minute value. The same procedure was repeated for all the subjects.

Scoring - The number of heart beats in one minute was recorded as score. (ACSM, 2006).

❖ **Fatigue Index** (Wang et al., 2023)

Purpose - To determine the Fatigue Index of the subjects.

Equipment and Materials - Stop watch and score sheet.

Procedure - The subject was asked perform Repeated Sprint Ability test. Marker cones, starting lines and timing gates are placed 20 meters apart to indicate the sprint distance. At the instructions of the timer, the subject places their foot at the starting line, waiting for the signal to 'go'. The stopwatch is started simultaneously with the first movement. The subject sprints maximally for 20m, ensuring that they do not slow down before reaching the end line. If a player's first sprint is not within 95 per cent of their previously recorded best 20 m sprint time, they will need to attempt the test again (after a 3-minute rest). If there are no timing gates, one stopwatch is used to time the sprint, the other continues to run. Record the time of the first sprint. In order to run the following sprint in the other direction, the subject turns and travels to the end of the 20-meter track. Twenty seconds after the start of the previous run, each 20-meter sprint begins. Before pressing "Go," players will be given a countdown with 10s, 3s, 2s, and 1s left. Starting 20 seconds, 40 seconds, 1 minute, 1 minute 20 seconds, etc. after the start of the first sprint, this cycle continues until ten sprints are finished.

Scoring - After recording each sprint time, a total time for the ten sprints is computed. The following formula determines the percentage decrement: (Total Time - (Best time x 10)) / Total Time x 100.

Picture 3: Fatigue Index Testing

HEMATOLOGICAL VARIABLES

- **i) Complete Blood Cell Morphology**

Purpose

To evaluate a total of three hematological parameters.

Equipment

Each subject's blood sample was collected and analyzed using a blood roller mixer, Sysmex automated hematology analyzer XP-100, 10 ml disposable syringe with needle, blood container with anticoagulant (EDTA), tourniquet, cotton, and methylated spirit.

Procedure

Collection of Blood Sample

Between 6.30 and 7.30 in the morning, blood samples were collected. After a 12-hour fast and a minimum of 24 hours without engaging in strenuous exercise, blood samples were obtained from the participants. The participants either sat or laid down in an armchair. To choose the vein for venous puncture, the left forearm's superficial veins were examined. After using spirit to clean the skin, it was left to dry. The upper arm has a tourniquet wrapped around it. To make the veins more noticeable, the individual was instructed to flex and stretch the wrist joint. The vein was fixed by gently pulling on the lower portion of the cleaned area with the thumb of the left hand. The syringe filled with blood as the vein was pierced. On the puncture, sterile cotton wool was applied and gently pushed. Each patient gave about 5 milliliters of blood, which were then placed in an EDTA anticoagulant tube.

Preparing the Blood in Roller Mixer

For a few minutes, anticoagulant tubes were placed on the blood roller mixer to increase the accuracy of the coagulation test. Preanalytical phase standardization could assist avoid laboratory errors and provide accurate test results for coagulation testing. (Aral & Usta, 2011)

Pre-operative blood sample analysis at the Sysmex automated hematology analyzer XP-100 Checks:

a) The power wire was connected correctly.

b) The printing paper within the analyzer was oriented correctly.

Inspection of reagents:

The analyzer machine's inlet aspiration nipple was associated with the reagent CELLPACK.

Details of CELLPACK					
Brand name	***volume***	***Storage temp.***	***Usage temp.***	***Shelf life after opening***	***Composition***
CELLPACK	10L/20L	5-30^0 C	15-30^0 C	60 days	Sodium chloride 6.38 g/l Boric acid 1.0 g/l Sodium tetraborate 0.2 g/l EDTA-2K 0.2 g/l

Switching on:

The power button was activated. The device was doing a self-check after turning on. This took about two minutes to complete.

Specimen requirement:

The researcher followed all instructions about the specimen requirement:

- A vein puncture was used to obtain a blood sample.
- A blood collection anticoagulant tube was used.
- The analyzer processed the sample in less than four hours after it was collected.
- Prior to final processing, three to five milliliters of whole blood were added to a sample tube with a 13 mm diameter.

Sample processing:

a) Verify that the whole blood mode analysis mode was selected and that the [Ready] indicator was shown on the instrument status indicator at the top of the display area.
b) The sample tube was inverted to mix the sample.
c) Removed the cap, being careful not to let the blood sample spill.
d) After the tube was adjusted to the sample probe, the [Start] switch was pressed.
e) The analysis got underway. [Aspirating] was displayed on the status display. The status display changed from [Aspirating] to [Running] mode once the sample aspiration process was finished. The sample was safely removed when [Running] was displayed.

Display of analysis results:

The LCD screen showed the analysis's most recent findings. Four screen pages with the entire set of findings were displayed.

Result print out:

By pressing the [Print out] key, the findings of the analysis of all hematological variables were printed out using the internal printer of the instrument.

End of the operation (shutdown):

a) After conducting every analysis, click the [Shutdown] button.
b) Pressed the start button after setting the CELLCLEAN to the sample probe.
c) As long as the "beep" continued, CELLCLEAN remained in the same state even if [Aspirating] was visible on the screen.
d) Verified that the shutdown procedure was finished.
e) Disconnected the primary power source.

CELLCLEAN	
To get rid of blood proteins, cellular residue, and lyse reagents that are still in the hydraulics of the device, apply this powerful alkaline detergent.	Sodium Hypochlorite (available chlorine concentration 5.0%)

❖ **Hemoglobin** (Perutz, 2022)

Purpose - To determine the Hemoglobin of the subjects.

Procedure - The participant was instructed to spend five minutes comfortably resting on a chair. After the blood sample was taken, the amount of hemoglobin in the blood was measured using the System XP-100 Automatic Hematology Analyzer.

Scoring - The quantity of Hemoglobin was recorded in g/dL.

- **Mean Corpuscular Hemoglobin (MCH) (**Bunn et al., 2020)

Purpose - To determine the Mean Corpuscular Hemoglobin (MCH) of the subjects.

Procedure - The participant was instructed to spend five minutes comfortably resting on a chair. Following the collection of the blood sample, the amount of MCH in the blood was measured using the System XP-100 Automatic Hematology Analyzer. **Scoring -** The quantity of MCH in Picogram/deciliter.

- **Red Blood Corpuscle (RBC)** (Lanza et al., 2021)

Purpose - To determine the Red Blood Corpuscle (RBC) of the subjects.

Procedure - The participant was instructed to spend five minutes comfortably resting on a chair. Following the collection of the blood sample, the amount of RBC in the blood was measured using the System XP-100 Automatic Hematology Analyzer.

Scoring - The quantity of RBC was recorded in x10 6 /µL.

Picture 4: Collecting Blood

COLLECTION OF DATA

The subjects were gathered and briefed on the purpose and specifications of the test items prior to the testing and experimental program. The subjects were requested and motivated for whole hearted participation towards success of the study. Before subjects were asked to perform the test, the tests was explained and demonstrated by the research scholar.

Control group was administrated to their routine training programme while experimental groups were exposed to hypoxic exposure with mask, without mask training programmes. The experimental training programmes were conducted for eight weeks. Precaution and importance were given to administration of the training programmes. Pre-tests in every criterion were conducted for the control and experimental groups prior to the execution of experimental training programs.

Pre-tests of all the variables was conducted for the experimental and control group prior to the experimental programme, then the researcher conducted a 8 weeks training programme on Hypoxic Exposure for mask group and without hypoxic exposure for non mask group.

While administering the programmes every care was taken for the subject to perform the work load given comfortably during initial four weeks. After four weeks the load parameters was increased progressively. The training programme was prepared for four day a week schedule and each experimental was performed training four sessions a week. The degree of flexibility in load intensity and volume was maintained to ensure that each subject's performance was within the acceptable range.

On the completion of experimental period of four weeks the during-tests was conducted to check the effect of training programmes. Following an eight-week training period, a post-test was administered to each group. The data for physiological variables performance was obtained with the help of various instruments and with the help of expert.

PILOT STUDY

The purpose of the pilot study was to determine whether the administration process with 10 participants could be implemented and to evaluate the subjects' preliminary susceptibility to adjusting the sub-maximal load of the workout session before finalizing the intermittent hypoxia training program. They were divided into two groups (mask and without mask) of five subjects each and both groups practices for 1 weeks (3 alternative day in a week) under the careful supervision of experts and the investigator and prescribing the adequate load for the experimental groups. This was done by regular checking of the pulse rate during training session. After seeing their preliminary state and their age factor, it was finalized that a heart rate of 101 to 126 beats per min. was the optimum for a sub-maximal load. The selected Physiological variables were measured according to the guidelines framed and based on the procedure to be adopted. Data was gathered for analysis, the pre- and post-tests were given, and the results were documented. Though the results of the pilot study were not significant but still some improvement (increase and decrease) trends were observed in some of the variables. For this final trial, an 8-week period was needed to obtain some meaningful and effective results, during which the load was gradually increased by increasing the volume. It was ensured that at the initial duration of the activities included in the intermittent hypoxic training, within the limitations of the subject's capacity to create the desired effects, based on the responses of the pilot study participants. This made it possible for the researcher to modify a training plan that was appropriate for each of the study groups and ensured that the fundamentals of sports training were adhered to.

RELIABILITY OF DATA

By determining the Tester's competency, Subject reliability, and Instrument reliability, the data dependability was guaranteed.

TESTER'S COMPETENCY

Reliability was established by the test-retest processes. Thirty participants from three groups were tested on selected variables. The repeated measurement of individuals on the same test is done to determine reliability. The data was different on different variables was obtained by the investigator himself with the help of supervisor working in the field of physical education and his fellow assistants. The investigator already had theoretical as well as practical knowledge of using these equipment for the measurement. Thus they were regarded competent enough for the purpose of the present study. Tester reliability in conducting tests VO_2 max, Max Heart Rate, Blood-Oxygen Saturation Level, Resting Heart Rate Fatigue Index, Hemoglobin, Mean Corpuscular Haemoglobin and Red Blood Corpuscles was established by test retest process.

The researcher and the expert on a randomly chosen sample were able to ascertain the consistency of the score results in this way. Table 2 displays the correlation coefficient.

Table-2

Coefficient of Correlation for Tester Reliability in Physiological and Hematological Variables

S.No	Variables	Coefficient of Correlation
1	VO_2 max	0.88*
2	Max pulse Rate	0.92*
3	Blood-Oxygen Saturation Level	0.97*
4	Resting Pulse Rate	0.92*
5	Fatigue Index	0.92*
6	Hemoglobin (HGB)	0.89*
7	Mean Corpuscular Hemoglobin (MCH)	0.96*
8	Red Blood Corpuscles (RBC)	0.93*

*Significant at 0.05 level of confidence

SUBJECTS RELIABILITY

Since the same subjects were employed by the same examiner in comparable circumstances, the intraclass correlation value of the aforementioned test and retest also demonstrated subject reliability.

Table 3

Coefficient of Correlation for Subject Reliability in Physiological and Hematological Variables

S.No	Variables	Coefficient of Correlation
1	VO_2 max	0.87*
2	Max pulse Rate	0.93*
3	Blood-Oxygen Saturation Level	0.96*
4	Resting Pulse Rate	0.91*
5	Fatigue Index	0.93*
6	Hemoglobin (HGB)	0.87*
7	Mean Corpuscular Hemoglobin (MCH)	0.93*
8	Red Blood Corpuscles (RBC)	0.92*

RELIABILITY OF THE INSTRUMENTS

For the measurement of the test results, the investigator used. The sport stop watches (Casio) used for monitoring the time of subjects performing in test items and subsequent intervals about which data was to be recorded, were standard automatic digital watches and were calibrated. The measuring tape used for the purpose of analyzing distance was calibrated. Also used in recording the data on selected variables were considered reliable. All the instruments used were standard and therefore their calibrations were accepted accurate enough for the purpose of the study and these instruments are being widely used throughout the India for research purpose. For that result were considered as reliable for conducting the present study.

TABLE-4: TRAINING SCHEDULE

Total Training is 30 mints (From 1st to 4 week)			
DAY	**Warming up**	**MAIN TRAINING**	**Cooling down**
MONDAY	5 MINT	➢ 20 sec high knee -----10 sec rest---------20 sec mountain climbers------10 sec rest x 5 times ➢ 20 sec pendulum swing------10 sec rest------20 sec bend over pendulum swings--------10 sec rest x 5 times ➢ 20 sec jumping jacks ------10 sec rest------------------------- 20 sec bend over jumping jacks----- 10 sec rest x 5 times	5 MINT
TUESDAY		**REST**	
WEDNESDAY	5 MINT	20 mints run and walk	5 MINT
THRUSDAY		**REST**	
FRIDAY	5 MINT	➢ 20 sec high knee -----10 sec rest---------20 sec mountain climbers------10 sec rest x 5 times ➢ 20 sec pendulum swing------10 sec rest------20 sec bend over pendulum swings--------10 sec rest x 5 times ➢ 20 sec jumping jacks ------10 sec rest------------------------- 20 sec bend over jumping jacks--- 10 sec rest x 5 times	5 MINT
SATUREDAY		**REST**	
SUNDAY	5 MINT	20 mints run and walk	5 MINT
Total Training is 40 mints (From 5th to 8 week)			
DAY	Warming up	**MAIN TRAINING**	Cooling down

MONDAY	5 MINT	✓ 20sec jump squats-----20sec plank-----20 sec rest **x** 4 times **1 mints rest** ✓ 20 sec jump lunges------20se-flutter kick squats--------1o sec rest **x** 4 times **1 mints Rest** ✓ 20sec pushup----20secburpees --------20sec rest**x** 4 times **1mint rest** ✓ 20sec rock climbers---------20 sec mason twists-------20 sec rest **x** 4 times **1 mints rest** ✓ 20 sec speed skaters-------20 sec froggers--------------20 sec rest **x** 4 times **1 mints rest** ✓ 20 sec truck jump--------20 sec-alternating side lunges------20 sec rest **x** 4times **1 mints rest**	5 MINT
TUESDAY		**REST**	
WEDNESDAY	5 MINT	30 mints run and walk	5 MINT
THRUSDAY		**REST**	
FRIDAY	5 MINT	✓ 20sec jump squats-----20sec plank-----20 sec rest **x** 4 times **1 mints rest** ✓ 20 sec jump lunges------20se-flutter kick squats--------1o sec rest **x** 4 times **1 mints Rest** ✓ 20secpushup----20secburpees --------20sec rest**x** 4 times	5 MINT

		1mint rest ✓ 20sec rock climbers---------20 sec mason twists-------20 sec rest **x** 4 times **1 mints rest** ✓ 20 sec speed skaters-------20 sec froggers--------------20 sec rest **x** 4 times **1 mints rest** ✓ 20 sec truck jump--------20 sec-alternating side lunges------20 sec rest **x** 4times **1 mints rest**	
SATUREDAY		**REST**	
SUNDAY	5 MINT	30 mints run and walk	5 MINT

Picture: 5 Training with mask

Picture: 6 Training without mask

Table 5: General structure of training program

Sl No.	Groups with training particulars	Training
1	Group A	Interval hypoxic training with mask
2	Group B	Interval hypoxic training without mask
3	Group C	Control group
4	Training duration	30 mints for 4 weeks
5	Training frequency	4 days in a week
6	Total load progression	40 mins for next 4 weeks
7	Total training duration	8 weeks

EXPERIMENTAL DESIGN

To determine the impact of sporadic hypoxic training on particular physiological factors The Randomized-Groups Pretest–Posttest Design was used.

STATISTICAL PROCEDURE

The collected data were properly examined using statistical techniques. The following statistical techniques were applied in this study:

- The dependability of the data was established by utilizing Pearson's product moment correlation.
- The significant mean difference between the pre- and post-test results of the intermittent hypoxic training was tested using analysis of covariance, independently for each of the three experimental groups (Group A: Mask, Group B: No Mask, and Group C: Control).
- Moreover, the least significant difference post hoc test was employed to determine which group was superior. The Statistical Package for Social Sciences (SPSS Version 26) was used to examine all of the data.

LEVEL OF SIGNIFICANCE

To compare the means of three separate groups—the Masked (Group A), the Without Masked (Group B), and the Control (Group C) Group—and to examine the difference between the Pre Treatment and Post Treatment Phase scores. To test the hypotheses, a significance level of 0.05 was established.

CHAPTER IV

ANALYSIS OF DATA AND RESULTS OF THE STUDY

CHAPTER IV

ANALYSIS OF DATA AND RESULTS OF THE STUDY

In this chapter, the analysis of data in Physiological and Hematological variables of male athlete, age ranged from 18 to 22 years were examined by Analysis of Co Variance (ANCOVA) in order to investigate the effect of Intermittent Hypoxic Training of eight weeks.

In case of having significant differences on the training Groups due to the Impact of eight weeks of Intermittent Hypoxic Training, post hoc-test was applied in order to find out the existence of significant differences on the training groups due to the Impact of eight weeks of training. The level of significance was set at 0.05 level of confidence.

<u>VO2 Max</u>

Findings

The statistical analysis of data on **VO2 Max** among two experimental groups (training with Mask, i.e. Group-A and training without Mask i.e. Group-B) and one control group i.e. Group-C was computed by applying analysis of Co-variance statistics which is presented in Table-6. The same is also graphically represented in Figure-4**.**

Table 6: Analysis of Co-variance of the means of VO2 Max among two experimental groups (Group-A and Group-B) and one control group (Group-C)

Variable	*Test*		*Mask Group (A)*	*Without Mask Group (B)*	*Control Group (C)*	*SOV*	*Sum of the Square*	*df*	*Mean Square*	*F – ratio*	*p-value*
VO2 Max	Pre test	Mean	57.923	57.493	57.493	B	1.233	2	.616	.868	.431
		SD	.59989	.91365	.96715	W	19.170	27	.710		
	Post test	Mean	58.321	57.695	57.271	B	5.581	2	2.790	3.482*	.045*
		SD	.78225	.93325	.95976	W	21.636	27	.801		
	Adjusted Post test	Mean	58.059	57.826	57.402	C	2.139	2	1.069	4.951*	.015*
						E	5.616	26	.216		

Significant at *$p < 0.05$ level of confidence.

Table value required for significance at 0.05 level with df 2,26 and 2,27 is 3.37 and 3.35.

As shown in table 6, the pre-test mean values on VO_2 Max for the Mask group, Without mask Group and control group was 57.923, 57.493 and 57.493 respectively. The obtained F value on the VO_2 Max. for the pretest means of both Experimental groups and control group was 0.868. This reveals that there is no Statistical difference **(*p=0.431 > 0.05*)** among the both Experimental groups and control group on VO_2 Max. before the completion of training protocol. It was inferred that the sample selection of the subjects for the all three groups were successful (Homogeneous).

The post-test means of VO_2 Max. of the Mask group, Without mask Group and control group was 58.321, 57.695 and 57.271 respectively, resulted in 'F'- ratio of 3.48, which indicates significant difference **(*p=0.045 < 0.05*)** among both the Experimental groups and control group on VO_2 Max. after the completion of training protocol.

The result was also inferred that the adjusted post test means of VO_2 Max. of the Mask group, Without mask Group and control group was 58.06, 57.83 and 57.40 respectively, resulted in a 'F'- ratio of 4.95, which indicates significant difference **(*p=0.015 < 0.05*)** among the both Experimental groups and control group on VO_2 Max. after the completion of training protocol.

Taking into consideration the differences of the pre test means, post test adjusted post test means were analyzed and it indicates that there is a significant difference in VO_2 Max among the both Experimental groups and the control group after the experimental period.

The selected dependent variables somewhat have been influenced due to the 8 weeks intervention programme, but the control group didn't show any improvement. In order to clarify the mean difference between the groups, the LSD (Least Significant Difference) post-hoc test was used by the researcher.

Table 7: The LSD post hoc Test for the VO_2 Max. means values

Groups	Groups	Mean Difference	*p- value*
Mask	Without mask	.233	.284
	Control	**.657***	.005
Without mask	Mask	-.233	.284
	Control	.424	.052
Control	Mask	**-.657***	.005
	Without mask	-.424	.052

Significant at *p < 0.05 level of confidence.

Table 7 shows that the adjusted post-test mean difference of **VO_2 Max.** among three groups. The said mean difference between Mask group and Control group was **0.657***, without mask group and Control groups was 0.424, and two training groups (Mask and Without Mask) was 0.233. The above Table revealed that significant differences exist between the means of Mask group and Control group ***(p= 0.005<0.05*).** It also revealed that Mask group was more effective than other two groups but Without Mask group was less effective than Mask group and more effective than Control group and Control group was less effective than other two groups. Concluded from the results it was found the Mask group was better than the Without Mask Group and control group.

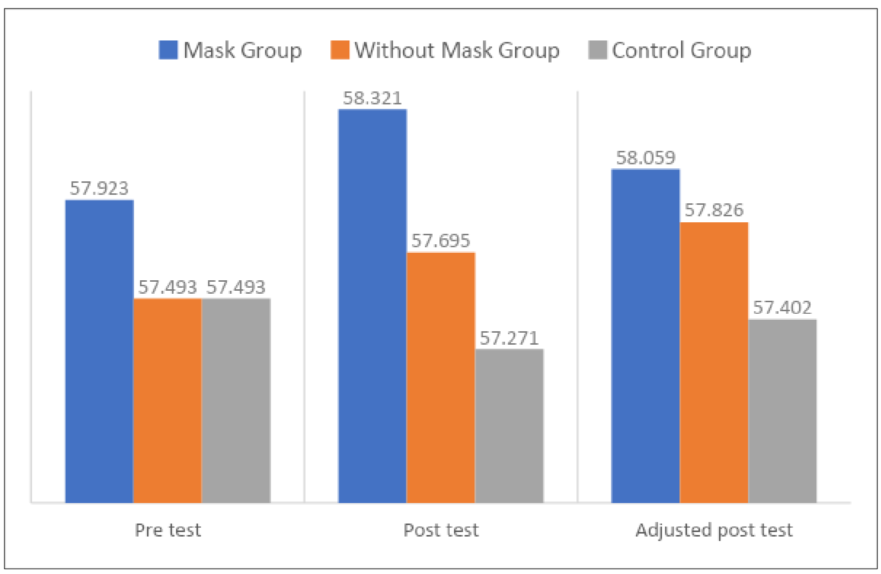

Figure 4: Graphical representation of means of VO2 Max among two experimental groups (Group-A and Group-B) and one control group (Group-C) in pre post- and adjusted post-test phases

Discussion of Findings

Elevation training masks create a sensation of breathing in thinner air, simulating high-altitude conditions. This, in turn, may lead to increased respiratory effort and potentially stimulate adaptations in the body. These adaptations may include an increase in red blood cell production and the release of certain hormones, which can improve oxygen delivery to the muscles and potentially enhance endurance performance.

The Elevation Training Mask is designed to create resistance during breathing, forcing the respiratory muscles to work harder. This increased resistance can lead to stronger respiratory muscles, allowing for improved ventilation and oxygen exchange during exercise. As a result, the body can utilize oxygen more efficiently, leading to an increase in VO2 max.

It's worth noting that other factors, such as training intensity, duration, and overall training program design, have a more significant impact on improving VO2 max Therefore, if you're aiming to enhance your VO2 max, it's generally recommended to focus on structured aerobic training programs that gradually increase exercise intensity and duration over time (Faiss et al., 2013).

The Table clearly indicates significant differences in VO2 max among two experimental groups (i.e. Group-A and Group-B). The group 'A', training with mask is considered to be better in VO2 max of the sedentary middle aged female individuals which may be due to the hypoxic environment.

From the aforesaid tables and figure, it was clearly noticed that the mean values of the training groups were found to be higher than that of the control group's mean value. Similar results were obtained by **Porcari et al (2016**) where large statistically significant between-group effects.

From such findings it may be assumed that although both the training were having some positive effect on the development VO2 max; however the effect of the with mask training program was found to be effective in improving VO2 max.

Hemoglobin

Findings

The statistical analysis of data on **Hemoglobin** among two experimental groups (training with mask, i.e. Group-A and training without mask i.e. Group-B) and one control group i.e. Group-C was computed by applying analysis of Co-variance statistics which is presented in Table-8. The same is also graphically represented in Figure-5**.**

Table 8: Analysis of Co-variance of the means of Hemoglobin among two Experimental groups (Group-A and Group-B) and one Control group (Group- C)

Variabl	*Test*		*Mask Group (A)*	*Without Mask Group (B)*	*Control Group (C)*	*SOV*	*Sum of the Square*	*df*	*Mean Square*	*F – ratio*	*Sig.*
	Pre test	Mean	14.30	14.05	14.02	B	.473	2	.236	0.935	.405
		SD	.50111	.67864	.21499	W	6.821	27	.253		
	Post test	Mean	14.37	14.11	14.01	B	.691	2	.345	1.409	.262
		SD	.49453	.65566	.24698	W	6.619	27	.245		
	Adjusted Post test	Mean	14.198	14.181	14.11	C	.042	2	.021	2.911	.072
						E	.188	26	.007		

***significant at 0.05 level of confidence.**

Table value required for significance at 0.05 level with df 2,26 and 2,27 is 3.37 and 3.35.

As shown in table 8, the pre-test mean values on Hemoglobin for the Mask group, Without mask Group and control group were 14.30, 14.05 and 14.02 respectively, the obtained F value on the Hemoglobin for the pre test means of both Experimental groups and control group was 0.935. This reveals that there is no Statistical difference **(*p=0.405 > 0.05*)** among the both Experimental groups and control group on Hemoglobin before the completion of training protocol. It was inferred that the sample selection of the subjects for the all three groups were successful (Homogeneous).

The post-test means of Hemoglobin of the Mask group, Without mask Group and control group was 14.37, 14.11 and 14.01 respectively, resulted in a 'F'- ratio of 1.41, which indicates no significant difference **(*p=0.262 > 0.05*)** among the both Experimental groups and control group on Hemoglobin after the completion of training protocol.

The result was also inferred that the adjusted post test means of Hemoglobin of the Mask group, Without mask Group and control group was 14.198, 14.181 and 14.11 respectively, resulted in a 'F'- ratio of 2.91, which indicates no significant difference **(*p=0.072 > 0.05*)** among the both Experimental groups and control group on Hemoglobin after the completion of training protocol.

Taking into consideration the differences of the pre test means, post test means and adjusted post test means were analyzed and it indicates that there is no significant difference in Hemoglobin among the both Experimental groups and the control group after the experimental period.

The above Table revealed that no significant difference exist between the means of Group-A & Group-B, and also no significant difference exists between Group-B & Group C and Group-A & Control Group respectively.

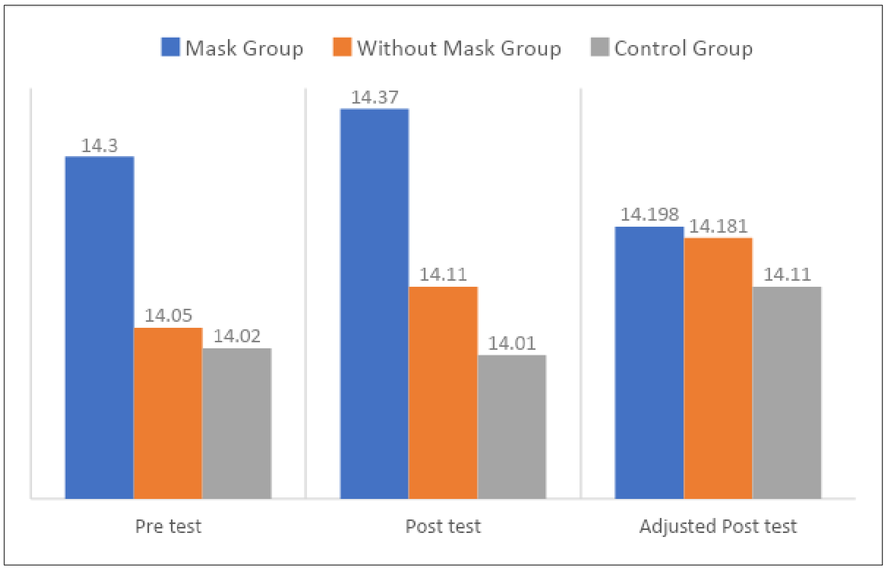

Figure 5: Graphical representation of means of Hemoglobin among two Experimental groups (Group-A and Group-B) and one Control group (Group-C) belonging to the middle aged sedentary females in pre post- and adjusted post-test phases

Discussion of Findings

Increased Hemoglobin (Hb) Concentration: At higher altitudes, where the air contains less oxygen, the body responds by producing more red blood cells, which contain hemoglobin. Hemoglobin is the protein in red blood cells that binds to oxygen in the lungs and carries it to the body's tissues. As the body adapts to the lower oxygen levels at altitude, it increases the production of hemoglobin to improve oxygen transport, allowing tissues and muscles to receive sufficient oxygen. Erythropoiesis: The process of producing new red blood cells is called erythropoiesis. When exposed to high altitudes, the kidneys sense the reduced oxygen levels and release a hormone called erythropoietin (EPO). EPO stimulates the bone marrow to produce more red blood cells, including hemoglobin. As a result, athletes who undergo altitude training may experience an increase in their blood's hemoglobin concentration, leading to enhanced oxygen-carrying capacity.

While the Elevation Training Mask aims to simulate altitude training and induce a mild hypoxic effect, the level of hypoxia created by the mask may not be sufficient or sustained enough to trigger significant increases in hemoglobin. For substantial changes in hemoglobin levels, more prolonged and sustained exposure to hypoxic conditions is typically required, as seen in traditional high-altitude training. Overall, the lack of a significant increase in hemoglobin after using the Elevation Training Mask does not necessarily mean the mask is ineffective for improving endurance performance. Athletes should consider the broader context of their training regimen, individual responses, and specific performance goals when incorporating the ETM into their training routine (Czuba et al., 2011).

The Table 8 and figure 5 clearly indicate no significant differences in Hemoglobin among two experimental groups (i.e. Group-A and Group-B). Twenty-four moderately trained subjects completed 8 weeks of high-intensity cycle ergometer training. Subjects were randomized into a mask (n = 10) or control (n = 10) group. Pre and post-training tests included VO_2max, pulmonary function, maximal inspiration pressure, hemoglobin and hematocrit. No significant differences were found in pulmonary function or hematological variables between or within groups **(Porcari et al., 2016)**

From such findings it may be assumed that both the Hypoxic training group with mask and without mask had no positive effect on the development of Hemoglobin. But partial improvement was notice of mask group than without mask and control group.

<u>Mean Corpuscular Hemoglobin (MCH)</u>

Findings

The statistical analysis of data on **Mean Corpuscular Hemoglobin (MCH)** among two experimental groups (training with mask, i.e. Group-A and training without mask i.e. Group-B) and one control group i.e. Group-C was computed by applying analysis of Co-variance statistics which is presented in Table-9. The same is also graphically represented in Figure-6**.**

Table 9: Analysis of Co-variance of the means of MCH among two experimental groups (Group-A and Group-B) and one control group (Group-C)

Variabl	***Test***		***Mask Group (A)***	***Without Mask Group (B)***	***Control Group (C)***	***SOV***	***Sum of the Square***	***df***	***Mean Square***	***F – ratio***	***Sig.***
	Pre test	Mean	29.16	29.27	28.85	*B*	.949	2	.474	.883	*.425*
		SD	.66366	.79169	.73824	*W*	14.510	27	.537		
	Post test	Mean	29.33	29.42	28.86	*B*	1.809	2	.904	1.722	*.198*
		SD	.59638	.78145	.78060	*W*	14.181	27	.525		
	Adjusted Post test	Mean	29.266	29.25	29.094	*C*	.171	2	.086	2.813	*.078*
						E	.792	26	.030		

***significant at 0.05 level of confidence.**

Table value required for significance at 0.05 level with df 2,26 and 2,27 is 3.37 and 3.35.

As shown in table 9, the pre-test mean values on MCH for the Mask group, Without mask Group and control group were 29.16, 29.27 and 28.85 respectively, the obtained F value on the

MCH for the pre test means of both Experimental groups and control group was 0.883. This reveals that there is no Statistical difference ***(p=0.425 > 0.05)*** among the both Experimental groups and control group on MCH before the completion of training protocol. It was inferred that the sample selection of the subjects for the all three groups were successful (Homogeneous).

The post-test means of MCH of the Mask group, Without mask Group and control group was 29.33, 29.42 and 28.86 respectively, resulted in a 'F'- ratio of 1.72, which indicates no significant difference ***(p=0.198 > 0.05)*** among the both Experimental groups and control group on MCH after the completion of training protocol.

The result was also inferred that the adjusted post test means of MCH of the Mask group, Without mask Group and control group was 29.266, 29.25 and 29.094 respectively, resulted in a 'F'- ratio of 2.81, which indicates no significant difference ***(p=0.078 > 0.05)*** among the both Experimental groups and control group on MCH after the completion of training protocol.

Taking into consideration the differences of the pre test means, post test means and adjusted post test means were analyzed and it indicates that there is no significant difference in Mean Corpuscular Hemoglobin (MCH) among the both Experimental groups and the control group after the experimental period.

The above Table revealed that no significant difference exist between the means of Group-A & Group-B, and also no significant difference exists between Group-B & Group C and Group-A & Control Group respectively.

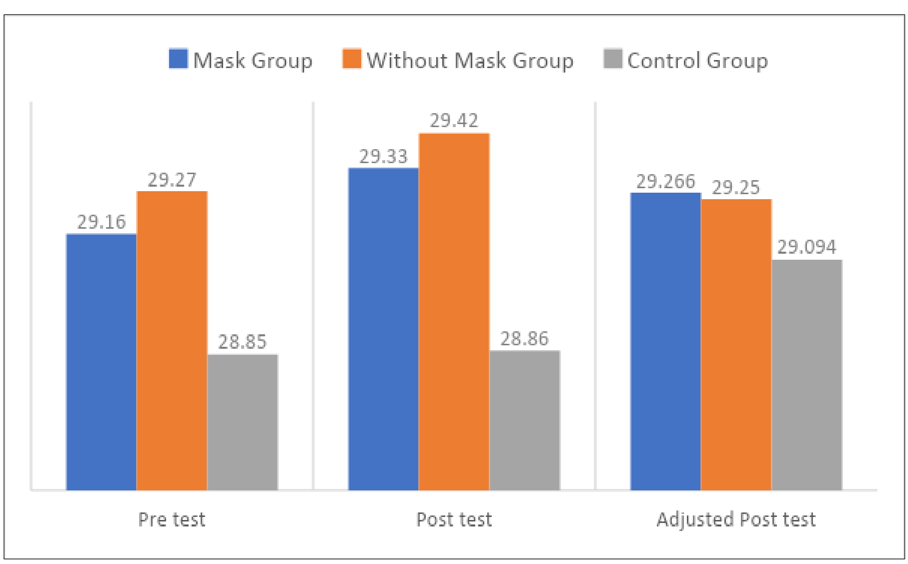

Figure 6: Graphical representation of means of MCH among two experimental groups (Group-A and Group-B) and one control group (Group-C) in pre post- and adjusted post-test phases

Discussion of Findings

The relationship between MCH (mean corpuscular hemoglobin) and high altitude training is complex and influenced by various physiological adaptations that occur at higher elevations.During high-altitude training, where oxygen availability is reduced due to lower atmospheric pressure, the body undergoes certain adaptive changes to cope with the decreased oxygen levels. One of the essential adaptations is an increase in the production of red blood cells (erythropoiesis) and hemoglobin, which helps improve the blood's oxygen-carrying capacity.Higher elevations lead to hypoxia, a state of reduced oxygen, and the body responds by producing erythropoietin (EPO), a hormone that stimulates red blood cell production in the bone marrow. This increase in red blood cells and hemoglobin allows the blood to carry more oxygen to the body's tissues, enhancing athletic performance in endurance-based activities.In theory, high altitude training can result in improved MCH levels because MCH is a measure of the amount of hemoglobin present in each red blood cell. With increased erythropoiesis and higher hemoglobin levels, the MCH value could rise. However, it's important to note that the relationship between high altitude training and MCH improvement is not linear for everyone. Individual responses to altitude training can vary significantly, and other factors such as genetics, nutrition, training intensity, and duration play critical roles in determining the overall impact on MCH levels (Kim et al., 2021).

Further, in aforesaid Tables and figure, it was also clearly noticed that the mean values of the experimental groups did not changed significantly from the pre-test phase to post- and adjusted post-test phases than that of the control group means.

From such findings it may be assumed that both the Hypoxic training group with mask and without mask had no positive effect on the development of MCH. But partial improvement was notice of mask group than without mask and control group.

Red Blood Corpuscles (RBC)

Findings

The statistical analysis of data on **Red Blood Corpuscles (RBC)** among two experimental groups (training with mask, i.e. Group-A and training without mask i.e. Group-B) and one control group i.e. Group-C was computed by applying analysis of Co-variance statistics which is presented in Table-10. The same is also graphically represented in Figure-7**.**

Table 10: Analysis of Co-variance of the means of RBC among two experimental groups (group-A and group-B) and one control group (group-C)

Variabl	***Test***		***Mask Group (A)***	***Without Mask Group (B)***	***Control Group (C)***	***SOV***	***Sum of the Square***	***df***	***Mean Square***	***F – ratio***	***Sig.***
	Pre test	Mean	5.01	5.01	4.989	B	.004	2	.002	.956	.397
		SD	.04163	.04695	.04149	W	.051	27	.002		
	Post test	Mean	5.175	5.091	4.989	B	.174	2	.087	3.308	.052
		SD	.25548	.08089	.08293	W	.708	27	.026		
	Adjusted Post test	Mean	5.169	5.080	5.007	C	.127	2	.063	2.568	.096
						E	.642	26	.025		

***significant at 0.05 level of confidence.**

Table value required for significance at 0.05 level with df 2,26 and 2,27 is 3.37 and 3.35.

The acquired F value on the RBC for the pre test means of both Experimental groups and the control group was 0.956, as shown in table 10. The pre-test mean RBC values for the Mask Group, Without Mask Group, and Control Group were 5.01, 5.01, and 4.989, respectively. This demonstrates that prior to the start of training, there was no significant difference in RBC between the Experimental and Control groups (p=0.397 > 0.05). Inferences were drawn about the homogeneity of the participants used to populate the three groups.

There was no statistically significant difference (p=0.052 > 0.05) between the Experimental groups and the control group on RBC after the start of Practice training (Mask group, Without mask Group, and control group post-test means of 5.175, 5.091, and 4.989, respectively; 'F'-ratio = 3.30).

The adjusted post-test means of RBC in the Mask group, Without mask Group, and control group were 5.169, 5.080, and 5.007, respectively; this resulted in a 'F'-ratio of 2.57, indicating that there was no significant difference (p=0.096 > 0.05) between the both Experimental groups and the control group on RBC following the start of Practice training.

Red blood cell (RBC) counts did not change significantly between the experimental groups and the control group after controlling for variations in pre- and post-test means as well as adjusted post-test means.

According to the data presented in the table above, there is no statistically significant difference between Group-A and Group-B means, and there is also no statistically significant difference between Group-B and Group C, and between Group-A and the Control Group.

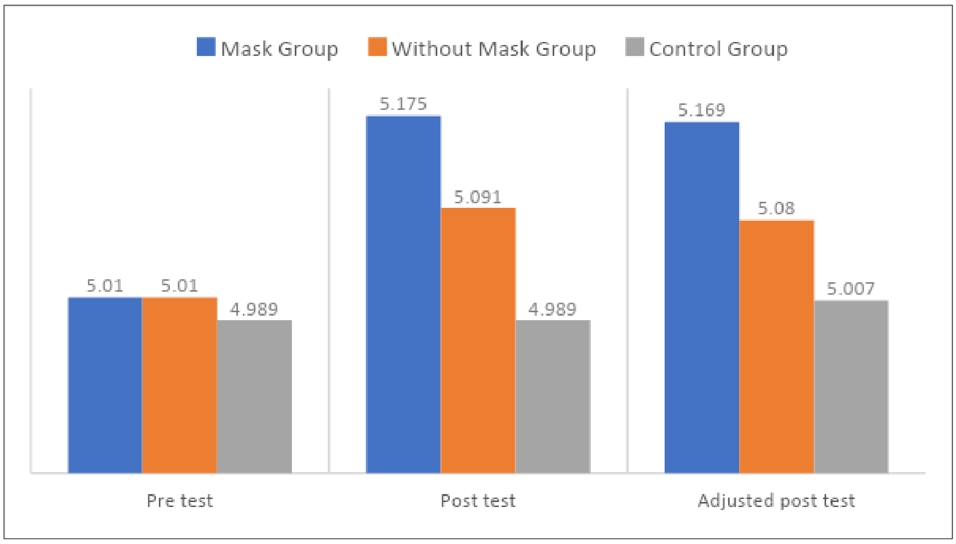

Figure 7: Graphical representation of means of RBC among two experimental groups (group- A and group-B) and one control group (Group-C) in pre post- and adjusted post-test phases.

Discussion of Findings

Altitude training involves exposure to lower oxygen levels seen at higher elevations. The ETM, on the other hand, largely limits airflow during breathing while maintaining a sea level oxygen content. It doesn't deplete the air of oxygen to the degree that happens at actual high elevations.

Hypobaric hypoxia, in which oxygen levels are lowered due to a drop in atmospheric pressure, is a common component of altitude training. The partial pressure of oxygen drops as a result. However, the ETM offers normobaric hypoxia, in which only the airflow during inhalation is limited and atmospheric pressure is maintained.

Systemic physiological adaptations, such as enhanced red blood cell production and alterations to the respiratory and cardiovascular systems, are induced by altitude training. While actual altitude training has been shown to induce these systemic changes, the ETM may not do so to the same degree (Park et al., 2016).

There are no statistically significant variations in RBC between Group-A and Group-B, as shown in Table 10 and Figure 7. According to Dr. Joseph A. Sheppard's (2021) research, red blood cell (RBC) counts dropped in the elevation training mask group. While hypoxic exercise may increase total RBC count, Grygorczyk and Orlov (2017) observed no significant change. When comparing RBC counts before and after 20 kilometres of hypoxic training, Hamlin et al., (2009) observed no significant difference. Interval hypoxic training (IHT), developed by Bernardi (2001), causes minor alterations in red blood cell (RBC) composition.

These results suggest that neither the hypoxic training group with mask nor the hypoxic training group without mask had any beneficial effects on RBC formation. However, the mask group showed statistically significant improvement compared to the no-mask and control groups.

Fatigue Index

Findings

The statistical analysis of data on **Fatigue Index** among two experimental groups (training with mask, i.e. Group-A and training without mask i.e. Group-B) and one control group i.e. Group-C was computed by applying analysis of Co-variance statistics which is presented in Table-11. The same is also graphically represented in Figure-8**.**

Table 11: Analysis of Co-variance of the means of Fatigue Index among Two Experimental groups (Group-A and Group-B) and one Control Group (Group-C)

Variabl	***Test***		***Mask Group (A)***	***Without Mask Group (B)***	***Control Group (C)***	***SOV***	***Sum of the Square***	***df***	***Mean Square***	***F – ratio***	***Sig.***
	Pre test	Mean	3.93	3.86	4.02	B	.126	2	.063	.902	.418
		SD	.35072	.17512	.23505	W	1.880	27	.070		
	Post test	Mean	4.08	3.88	4.03	B	.217	2	.108	1.041	.367
		SD	.47633	.17583	.23344	W	2.811	27	.104		
	Adjusted Post test	Mean	4.091	3.961	3.950	CB	.124	2	.062	1.876	.173
						E	.860	26	.033		

***significant at 0.05 level of confidence.**

Table value required for significance at 0.05 level with df 2,26 and 2,27 is 3.37 and 3.35.

The F value on the Fatigue Index for the pre-test means of both Experimental groups and the control group was 0.902, as shown in table 11. The pre-test mean values for the Mask group, Without mask Group, and control group were 3.93, 3.86, and 4.02, respectively. No significant difference was found between the experimental and control groups on the Fatigue Index prior to the start of Practice training ($p=0.418 > 0.05$). Inferences were drawn about the homogeneity of the participants used to populate the three groups.

The Fatigue Index post-test means for the Mask group, Without mask Group, and control group were 4.08, 3.88, and 4.03, respectively; this resulted in a 'F'-ratio of 1.04, indicating there was no significant difference ($p=0.367 > 0.05$) between the two Experimental groups and the control group.

Adjusted post-test means of Fatigue Index for the Mask group, Without mask Group, and control group were 4.091, 3.961, and 3.95, respectively; this resulted in a 'F'-ratio of 1.87, indicating that there was no significant difference ($p=0.173 > 0.05$) between the both Experimental groups and the control group on Fatigue Index after the start of Practice training.

After adjusting for variations between pre- and post-test averages, it was shown that neither the Experimental nor the Control groups had significantly different Fatigue Indices from one another after the experiment period.

According to the data presented in the table above, there is no statistically significant difference between Group-A and Group-B means, and there is also no statistically significant difference between Group-B and Group C, and between Group-A and the Control Group.

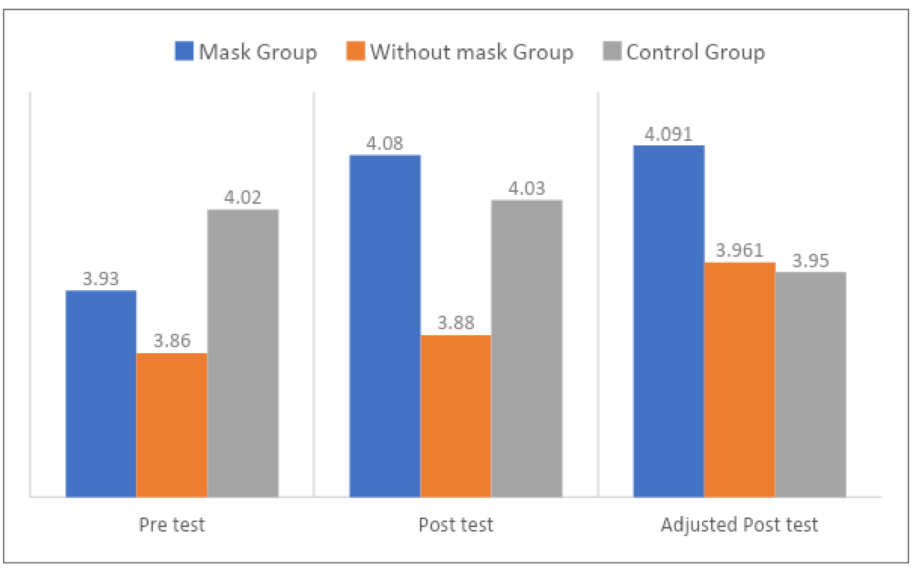

Figure 8: Graphical representation of means of Fatigue Index among two experimental groups (Group-A and Group-B) and one control group (Group-C) in pre post- and adjusted post-test phases

Discussion of Findings

No credible studies exist that detail the effects of elevation training masks on tiredness index. Many physiological changes, including increased red blood cell synthesis, enhanced oxygen-carrying capacity, and altered muscle metabolism, have been linked to high-altitude exercise. These changes may have an effect on how quickly athlete tired while exercising.

Elevation training masks are designed to limit airflow during exercise, simulating a high-altitude environment and so increasing the demand placed on the respiratory muscles. This enhanced respiratory effort may contribute to improved respiratory muscle endurance and potentially alter fatigue onset.

There isn't enough data yet to say whether or not elevation training masks do work to reduce fatigue. The use of an elevation training mask has been linked in some research to a training impact on the respiratory muscles, which may have advantages in delaying exhaustion during exercise. However, other research has not indicated that using an elevation training mask significantly improves performance or tiredness indices.

It's vital to consider that tiredness development during exercise is influenced by several elements, including cardiovascular fitness, muscle strength, endurance, and individual variability. While high-altitude training might cause physiological changes that may affect tiredness, the precise effects of elevation training masks on fatigue index are not well-established (Herms et al., 2011).

There are no statistically significant variations in Fatigue Index between the two experimental groups (i.e. Group-A and Group-B), as shown in Table 11 and Figure 8. High-intensity interval training (HIIT), created by Segizbaeva and Aleksandrova (2018) to improve respiratory muscle function, may assist postpone respiratory muscle tiredness and boost endurance performance. A study that compared the effects of altitude training to those at sea level found that the former may help reduce muscle fatigue by increasing erythropoietin (EPO) production.

These results suggest that neither the Hypoxic training group with mask nor the one without mask contributed favourably to the growth of the Fatigue Index. However, the mask group showed statistically significant improvement compared to the no-mask and control groups.

O2 Saturation Level

Findings

The statistical analysis of data on **O2 Saturation Level** among two experimental groups (training with mask, i.e. Group-A and training without mask i.e. Group-B) and one control group i.e. Group-C was computed by applying analysis of Co-variance statistics which is presented in Table-12. The same is also graphically represented in Figure-9**.**

Table 12: Analysis of Co-variance of the means of O2 Saturation Level among two experimental groups (Group-A and Group-B) and one control group (Group- C)

Variabl	***Test***		***Mask Group***	***Without Mask Group***	***Control Group***	***SOV***	***Sum of the Square***	***df***	***Mean Square***	***F – ratio***	***Sig.***
	Pre test	Mean	96.6	96.5	96.2	B	.867	2	.433	.936	.405
		SD	.69921	.52705	.78881	W	12.500	27	.463		
	Post test	Mean	97.2	97.1	96.3	B	4.867	2	2.433	3.189	.057
		SD	.91894	.73786	.94868	W	20.600	27	.763		
	Adjusted Post test	Mean	97.084	97.054	96.462	C	2.303	2	1.152	2.058	.148
						E	14.545	26	.559		

***significant at 0.05 level of confidence.**

Table value required for significance at 0.05 level with df 2,26 and 2,27 is 3.37 and 3.35.

Pre-test mean values for O2 Saturation Level in the Mask group, Without mask Group, and control group are reported in table 6 to be 96.6, 96.5, and 96.2, respectively, and a F value of 0.936 was obtained when comparing the means of the Experimental groups with those of the control group. This demonstrates that there is no Statistical difference ($p=0.405 > 0.05$) among the both Experimental groups and control group on O2 Saturation Level before the onset of Practice training. Inferences were drawn about the homogeneity of the participants used to populate the three groups.

The post-test means of O2 Saturation Level for the Mask Group, W ithout Mask Group, and Control Group were 97.2, 97.1, and 96.3, respectively, yielding a 'F'- ratio of 3.19, indicating no significant difference ($p=0.057 > 0.05$) between the two Experimental groups and the control group.

Adjusted post-test means of O2 Saturation Level for the Mask group, Without mask Group, and control group were 97.084, 97.054, and 96.462 respectively; this resulted in a 'F'-ratio of 2.05, indicating no significant difference ($p=0.148 > 0.05$) between the both Experimental groups and the control group on O2 Saturation Level after the start of Practice training.

When comparing the experimental groups to the control group, no significant variations in O2 saturation were found after accounting for differences in pre- and post-test means as well as corrected post-test means.

According to the data presented in the table above, there is no statistically significant difference between Group-A and Group-B means, and there is also no statistically significant difference between Group-B and Group C, and between Group-A and the Control Group.

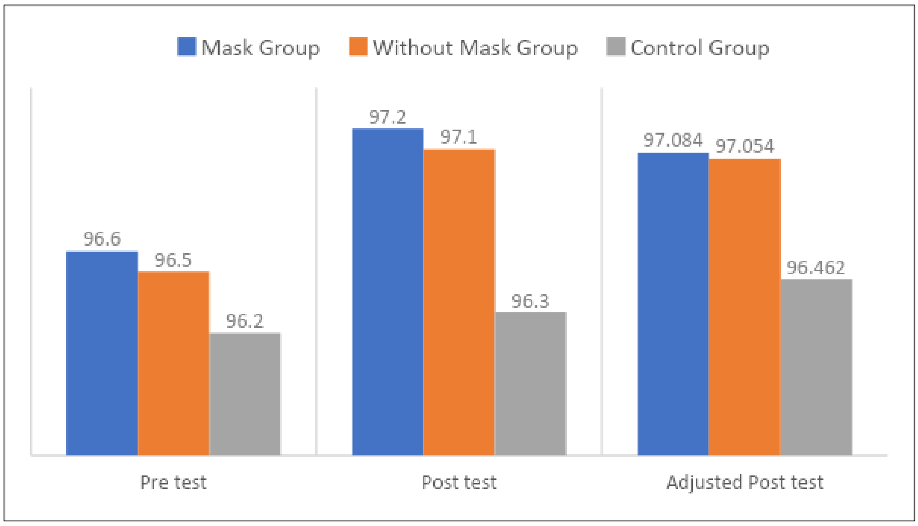

Figure 9: Graphical representation of means of O2 Saturation Level among two experimental groups (group-A and group-B) and one control group (Group-C in pre post- and adjusted post-test phases

The pre-test results of three groups of athletes (Group-A, Group-B, and a control group) showed no significant differences in O2 Saturation Level (sig. 0.405>0.05 at 2,27 degree of freedom at the 0.05 level of significance; see Table 12 and Figure 9). There was no statistically significant difference between the two experimental groups and the control group when the last test was administered (p=0.057 with a degree of freedom of 2.27). Both the post-test and the adjusted post-test had significance levels greater than 0.05.

Discussion of Findings

Whether by using an elevation training mask or not, the goal of elevation training is to produce adaptations similar to those experienced at high altitude. However, rather than immediately raising oxygen saturation, the physiological changes occurring from elevation training are connected to the body's ability to utilise and transport oxygen more efficiently.

Keep in mind that exercising with the ETM is not the same as actual altitude training, in which athletes adapt to lower oxygen levels by travelling to higher altitudes. SpO2 levels may fluctuate over time as a result of adaptations brought on by altitude training, such as an increase in red blood cells and enhanced oxygen-carrying capacity.

Administering supplementary oxygen would be the most straightforward way to improve oxygen saturation levels. When oxygen levels drop too low, such in a hospital or on a high-altitude trip, it's usual Practice to supplement with oxygen.

Overall oxygen saturation does not increase with elevation training, but the body's ability to use and transport oxygen is enhanced. Oxygen saturation levels in the body are principally affected by the air's oxygen content and the efficiency of the respiratory and circulatory systems.

To mimic the effects of exercising at higher altitudes, the ETM is made to generate a slight resistance when breathing. While the mask may cause a small drop in SpO2 due to increased breathing resistance, these changes are typically within a safe range and may not lead to large increases in oxygen saturation (Hoppeler et al., 2008).

The Table 12 and image 9 clearly reveal no significant changes in O2 Saturation Level among two experimental groups (i.e. Group-A and Group-B). Mathew et al., (2020) created oxygen saturation values to describe the amount to which hemoglobin is bound or saturated with oxygen. At altitudes more than 1,500 metres, "Arterial hemoglobin oxygen saturation" (SaO2) is shown to decline, as reported by Goldberg et al., 2012. Eroglu1 et al. (2018) found no statistically significant effects of acute aerobic exercise on athletes' arterial blood oxygen saturation. The oxygen saturation level of children aged 12 was observed to decrease with increasing altitude up to 2500 m by Ucros et al. (2020).

Based on these results, it can be concluded that neither the hypoxic training group with mask nor the hypoxic training group without mask contributed to the improvement of O2 Saturation Level. However, the mask group showed statistically significant improvement compared to the no-mask and control groups.

Maximum pulse Rate (MPR)

Findings

The statistical analysis of data on **Maximum pulse Rate (MPR)** among two experimental groups (training with mask, i.e. Group-A and training without mask i.e. Group-B) and one control group i.e. Group-C was computed by applying analysis of Co-variance statistics which is presented in Table-13. The same is also graphically represented in Figure-10**.**

Table 13: Analysis of Co-variance of the means of Maximum pulse Rate among two experimental groups (Group-A and Group-B) and one control group (Group- C)

Variable	***Test***		***Mask Group (A)***	***Without Mask Group (B)***	***Control Group (C)***	***SOV***	***Sum of the Square***	***df***	***Mean Square***	***F – ratio***	***Sig.***
	Pre test	Mean	175.800	175.000	175.200	B	3.467	2	1.733	.880	.426
		SD	1.47573	1.49071	1.22927	W	53.200	27	1.970		
	Post test	Mean	176.1000	175.2000	175.3000	B	4.867	2	2.433	1.702	.201
		SD	1.19722	1.22927	1.15950	W	38.600	27	1.430		
	Adjusted Post test	Mean	175.718	175.473	175.409	C	.503	2	.251	2.280	.122
						E	2.868	26	.110		

***significant at 0.05 level of confidence.**

Table value required for significance at 0.05 level with df 2,26 and 2,27 is 3.37 and 3.35.

The pre-test mean MPR values for the Mask Group, Without Mask Group, and Control Group were 175.80, 175, and 175.20, respectively, and the obtained F value on the MPR for the pre-test means of both Experimental Groups and Control Group was 0.880. Before the start of practice training, there was no significant difference (p=0.426 > 0.05) in MPR between the experimental and control groups. Inferences were drawn about the homogeneity of the participants used to populate the three groups.

After practice training had begun, there was no significant difference (p=0.201 > 0.05) in O2 Saturation Level between the Experimental groups and the control group, as measured by the post-test means of MPR in the Mask group, Without mask Group, and control group, respectively, which resulted in a 'F'-ratio of 1.70.

With an adjusted post-test mean of 175.72, 175.47, and 175.41 for the Mask group, Without mask group, and control group, respectively, and a 'F'-ratio of 2.28, it was determined that there was no statistically significant difference (p=0.122 > 0.05) between the Experimental groups and the control group on MPR following the start of Practice training.

Maximum pulse rate (MPR) data from the experimental groups and the control group show no statistically significant differences after controlling for differences in pre- and post-test means and adjusted post-test means.

According to the data presented in the table above, there is no statistically significant difference between Group-A and Group-B means, and there is also no statistically significant difference between Group-B and Group C, and between Group-A and the Control Group.

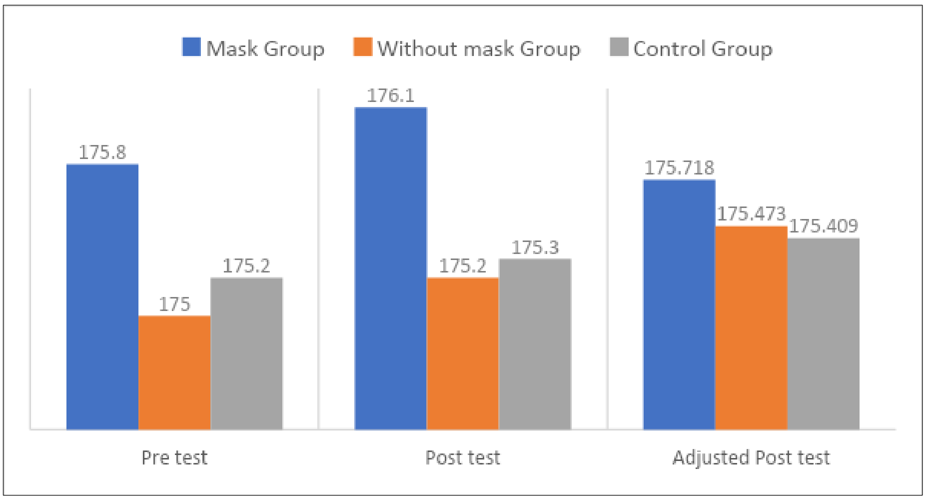

Figure 10: Graphical representation of means of Maximum Pulse Rate among two experimental groups (group-A and group-B) and one control group (Group-C) in pre post- and adjusted post-test phases

Discussion of Findings

The maximal pulse rate is primarily controlled by factors such as age, genetics, and total cardiovascular fitness. The use of elevation training masks or any other form of elevation training has no effect on these variables.

While high-altitude training can cause some physiological adaptations, such enhanced red blood cell synthesis and improved oxygen-carrying capacity, it has little effect on a person's maximum heart rate. The demand for oxygen and the capacity of the cardiovascular system to supply it are primary factors in the exercise-induced increase in heart rate. The maximal heart rate is not directly affected by elevation training, although it may boost cardiovascular fitness and the efficiency with which oxygen is used.

The Elevation Training Mask (ETM) is a device that, by providing resistance during breathing, mimics the effects of training at high altitudes. While the ETM may result in greater respiratory effort and cardiovascular demands during exercise, it is vital to remember that it does not directly control or impact an individual's maximal pulse rate.

It's a measure of how hard someone is working out and how fast their heart is beating. Training masks and respiratory muscle training devices like the ETM have little to no effect on maximal heart rate, which is primarily controlled by age, genetics, fitness level, and health state.

During physical activity, the ETM may have an indirect effect on heart rate by raising breathing effort and, consequently, the sensation of exertion. Some people may reach their heart rate maximum (HRmax) earlier as a result of this during high-intensity activity. Contrary to popular belief, the ETM does not elevate the maximal heart rate above what is considered normal by the body (Messonnier et al., 2004).

Maximum pulse rate between the two experimental groups (Group-A and Group-B) is not significantly different, as shown in Table 13 and Figure 10. Using an elevation training mask, Oncen (2018) tested six volunteers and found no statistically significant improvement in MPR. With increasing hypoxia, Mourot (2018) showed that MPR decreased with altitude. Similarly, Mourot (2017) discovered that MPR drops at high altitude as a function of both time spent there (acclimatisation) and altitude. Morgan et al., (2012) showed no significant variations in MPR on training with elevation training mask.

These results suggest that neither the hypoxic training group with mask nor the hypoxic training group without mask contributed to the growth of Maximum pulse Rate. However, the mask group showed statistically significant improvement compared to the no-mask and control groups.

Resting Pulse Rate (RPR)

Findings

The statistical analysis of data on **Resting Pulse Rate (RPR)** among two experimental groups (training with mask, i.e. Group-A and training without mask i.e. Group-B) and one control group i.e. Group-C was computed by applying analysis of Co-variance statistics which is presented in Table-14. The same is also graphically represented in Figure-11.

Table 14: Analysis of Co-variance of the means of Resting Pulse Rate among two experimental groups (Group-A and Group-B) and one control group (Group- C)

Variable	Test		Mask Group (A)	Without Mask Group (B)	Control Group (C)	SOV	Sum of The Square	df	Mean Square	F –ratio	Sig.
	Pre test	Mean	73.2000	73.2000	73.7000	B	1.667	2	.833	.889	.423
		SD	1.03280	.91894	.94868	W	25.300	27	.937		
	Post test	Mean	72.9000	73.000	73.6000	B	2.867	2	1.433	2.005	.154
		SD	.73786	.94281	.84327	W	19.300	27	.715		
	Adjusted Post test	Mean	73.032	73.132	73.336	C	.456	2	.228	1.698	.203
						E	3.490	26	.134		

***significant at 0.05 level of confidence.**

Table value required for significance at 0.05 level with df 2,26 and 2,27 is 3.37 and 3.35.

Table 14 shows that the mean RPR scores prior to testing were 73.20 for the Mask group, 73.20 for the Without mask group, and 73.70 for the control group. The F value for the RPR prior to testing means of the Experimental groups and the control group was 0.889. This shows that there was no significant variation in RPR between the experimental and control groups before the start of Practice training ($p=0.423 > 0.05$). Inferences were drawn about the homogeneity of the participants used to populate the three groups.

There was no statistically significant difference ($p=0.154 > 0.05$) in RPR between the Experimental groups and the control group after the start of Practice training (mean RPR of 72.90 for the Mask group, 73 for the Without mask Group, and 73.60 for the Control group; 'F'-ratio = 2.00).

After Practice training began, the adjusted post-test means of RPR for the Mask group, Without mask Group, and control group were 73.03, 73.13, and 73.33, respectively; this resulted in a 'F'-ratio of 1.70, indicating that there was no significant difference ($p=0.203 > 0.05$) between the both Experimental groups and the control group on RPR.

It was determined that after the experimental period, there was no discernible difference in Resting Pulse Rate (RPR) between the Experimental groups and the control group, as measured by comparing pre- and post-test means as well as post-test and adjusted post-test means.

According to the data presented in the table above, there is no statistically significant difference between Group-A and Group-B means, and there is also no statistically significant difference between Group-B and Group C, and between Group-A and the Control Group.

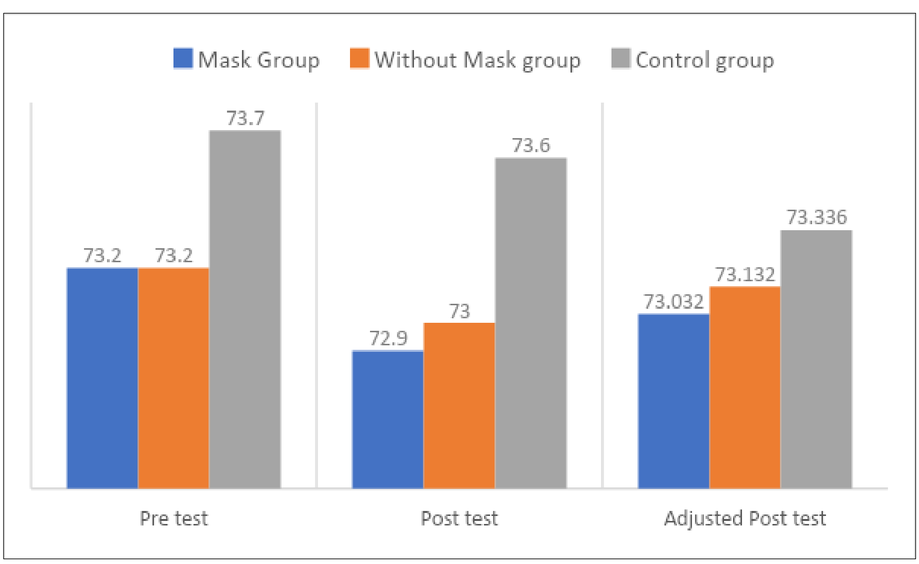

Figure 11: Graphical representation of means of Resting Pulse Rate among two experimental groups (group-A and group-B) and one control group (Group-C) in pre post- and adjusted post-test phases

Discussion of Findings

Resting pulse rate is mostly regulated by cardiovascular fitness. While exercising at high altitudes might result in some adaptations in the body, such as enhanced red blood cell formation, improved oxygen-carrying capacity, and changes in respiratory function, these changes may not necessarily have an immediate effect on resting heart rate.

A person's cardiovascular fitness and general health can be gauged in part by their resting pulse rate. Exercise, especially cardiovascular training, can help lower your resting heart rate over time. However, the particular modalities and techniques of training employed may vary according to the needs and preferences of the trainee.

Keep in mind that scientific knowledge and investigation always develop and advance. The effects of elevation training on the resting heart rate have been the subject of recent research and discovery.

Changing one's resting heart rate (pulse rate) is secondary to the primary goals of utilising the Elevation Training Mask, which are the training of respiratory muscles and the improvement of respiratory endurance. While the ETM may have an indirect impact on cardiovascular responses during exercise, it is not intended to change resting heart rate.

Resting heart rates did not differ between the experimental groups (Group-A and Group-B), as shown in Table 14 and Figure 11. Oncen (2018) used an elevation training mask on 6 participants, but observed no statistically significant improvement in resting pulmonary resistance (RPR). Increased oxygen consumption during exercise is responsible for the decrease in resting pulmonary blood flow (RPR) observed in long-term training at high altitude (Grover et al., 1986). The effect of long-term high altitude exposure on resting and post-exercise recovery RPR was not observed to be significantly different by Bhattarai et al. (2018). The RPR was observed to be reduced with routine exercise in hypoxic conditions by Reimers et al. (2018).

From such findings it may be assumed that both the Hypoxic training group with mask and without mask had no favourable effect on the growth of Resting Pulse Rate (RPR). However, the mask group showed statistically significant improvement compared to the no-mask and control groups.

Testing of Hypothesis

In the introductory chapters, it was hypothesized that, it was assumed that males would not show any appreciable physiologic improvement after undergoing intermittent Hypoxic training.

Significant gains in VO2 max were seen after 8 weeks of intermittent Hypoxic training. Thus, the null hypothesis was rejected with a 0.05 probability. Null hypothesis was accepted because there were no differences in maximal pulse rate, blood-oxygen saturation, exhaustion index, or resting pulse rate.

Further in the introductory chapters, Hypoxic training was also hypothesised to have no discernible effect on certain hematological variables in males.

There was no discernible change in HBG, MCH, or RBC after 8 weeks of intermittent hypoxic training. Thus, the 0.05 significance level was sufficient to reject the null hypothesis.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

Hypoxic training is used by many athletes, coaches, and sports scientists to help them perform better at sea level. There are a number of ways to train in altitude/hypoxia, including LHTH and LHTL. Living low training high (LLTH) methods have been increasingly popular in recent years as a means of altitude/hypoxic training. Athletes live near to sea level but exercise at elevations of 2,000 to 4,500 metres during these training sessions (Faiss et al., 2013).

IHT (Intermittent Hypoxic Training) training may be appealing to coaches and athletes because it often involves a shorter hypoxia exposure time and length. This form of hypoxia exposure occurs twice weekly over a period of two to six weeks and lasts for less than three hours each time. McLean, A., et al. (2014). Resting hypoxia exposure involves 3-5 minutes of low-oxygen air exposure followed by normal air exposure. Five minutes on, five minutes off, every hour: that's a common routine. Using a pulse oximeter, oxygen saturation levels are measured. You should go for an 85% mask-on success rate and a 95% mask-off success rate. Tolerance, ventilation response, and acclimatisation are all improved by brief hypoxia exposure at high elevations. Exercise-induced gains in aerobic exercise capacity can be amplified by combining the mental stress of training with the physiological stress of hypobaric or normobaric hypoxic exposure (Czuba et al., 2011).

The purpose of this study was to examine the effectiveness of the widely-used hypoxic training programme among male Barabani athletes. The researcher researched the effects of hypoxia training in conjunction with elevation training mask by concentrating on a few physiological variables.

Thirty male athletes, aged 18 to 22, were selected at random to help the researcher reach his goals. Then, the thirty participants were randomly assigned to one of two experimental groups and one control group (that received no training). There were ten people in Group A (training with elevation training mask), ten in Group B (training without elevation training mask), and ten in Group C (control group).

For Groups A and B [Monday-Weekend-Friday-Sunday], the researcher individually conducted four sessions per week, each lasting 30 minutes for the first four weeks and 40 minutes for the fifth and eighth. This continued weekly for a total of eight weeks. After participants signed their NOCs, their medical histories were recorded and preliminary data was collected in preparation for their training sessions with the scholars. Following the training session, the researcher, with the help of another expert, gathered more data from the same individuals on the same parameters. Data collected prior to training (pre-data) and data collected after training (post-data) were then analysed using an analysis of covariance (ANCOVA).

During the pre-post and post-adjusted testing phases, physiological and haematological variables were compared between the three groups: Group A, which was trained with a hypoxic training mask; Group B, which was not; and Group C, which was not trained. Statistical analysis of covariance was employed to look for differences between these factors.

Using the post hoc test (LSD), we compared the means of the three groups (Group A, which trained with a mask; Group B, which trained without a mask; and Group C, which did not participate in the training regimen) to see if there was a statistically significant difference between them. A 5% level of confidence was used to assess the degree of significance.

Table 15: Physiological and Hematological variables

Physiological Variable	VO2 Max
	Oxygen saturation Level
	Maximum Pulse Rate
	Resting Pulse rate
	Fatigue Index
Hematological Variable	Hemoglobin
	Red Blood Corpuscle
	Mean Corpuscular Hemoglobin

When comparing the Experimental groups using elevation training masks to the Control group, the results showed that the former had significantly different mean values for all parameters. WHEN compared to the results of the control group, the training group outperformed the control group in every single metric. Last but not least, Group A improved a few parameters more quickly than Group B, the other training group.

From the results of an intermittent hypoxia training plan lasting 8 weeks, we were able to derive the following conclusions.

- Although the Elevation Training Mask (ETM) can simulate some of the mild hypoxia observed at high altitudes by restricting airflow, it may not be able to recreate the severe hypoxia experienced there. Physiological adaptations may not occur in healthy people who are exposed to hypoxia for short or long periods of time.
- To mimic the effects of exercising at high elevations, the Elevation exercising Mask (ETM) makes breathing more difficult during exercise. It's promoted under the false premise that it will allow users to "train as if" they are at a greater altitude, where oxygen levels are lower.
- Keep in mind that the ETM may provide a moderate hypoxic influence, but it cannot completely replicate the physiological conditions of actual altitude training. By lowering the partial pressure of oxygen, training at high elevations mimics real-world hypoxia. Increases in oxygen-carrying capacity and new red blood cell production are only two of the many positive physiological adaptations that may be prompted by this type of exercise.
- However, using the ETM makes it more challenging to breathe because it activates only when you exhale. The amount of oxygen in the air is unaffected, but you may find yourself breathing more rapidly and taking in less oxygen as a result. That's why we didn't see the same physiological reactions from ETM use as we did from actual altitude training.
- Experts are divided on whether or not the ETM can successfully simulate altitude training and cause the same changes as exercising at high elevations, despite the fact that its use has been shown to improve respiratory muscle strength and endurance. While some studies have found conflicting results, others have found potential advantages. If an athlete wishes to experience the physiological changes that come with altitude training particularly, then using the ETM may not be as successful as actual training at higher elevations or using altitude chambers/tents under expert supervision.

- Long-term, consistent use of the ETM may also degrade its performance. Consistent, extended use of the mask, as opposed to occasional, brief use, is more likely to result in the same adjustments.
- Depending on one's motivations for exercising, the ETM's efficiency may vary from user to user. It may increase the strength and endurance of the respiratory muscles, although its effects on performance measures like VO2max and cardiovascular adaptations are still unknown.

CONCLUSIONS

The following observation were concluded in the study.

1) When compared to training in a control group or without a mask, intermittent hypoxia training is more successful at raising VO2 Max.
2) However, it turns out that both the masked and non-masked groups fared better than the control group. The non-masked participants in the masked group outperformed those in the control group, when compared to the control group.

RECOMMENDATIONS

1) The physiological and health-related physical fitness of men across age groups may benefit from hypoxic training in conjunction with elevation training masks.
2) Hypoxia training may increase physical fitness, cardiovascular fitness, power, and strength, and it might be studied in high school and college-aged males and females.
3) It is possible to study how middle-aged men's mental health, recovery heart rate, and health-related fitness are affected by hypoxia training.
4) The benefits of hypoxia training could also be studied in older adults who have musculoskeletal problems and low levels of health-related physical fitness.
5) To investigate the physiological consequences of a hypoxia training regimen at varying intensities, an elevation training mask can be employed.
6) Multiple Interval Hypoxic Training procedures would allow for comparable research.
7) The concept of specificity might be considered while choosing an exercise programme with a particular objective in mind.
8) Similar studies may be undertaken on adult athletes, but with a wider range of controls.

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APPENDICES

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Effect of hypoxic training with elevation training mask on VO_2 max

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Abstract
The underlying mechanisms of hypoxic training with elevation training mask are still a very vast discipline of research work and has been proved and implemented by the trainers and coaches. The purpose of the study was to find out the effect of Hypoxic training with elevation training mask on VO_2 max. Thirty physically fit individuals (age 17-22) of Baraboni club of Asansol, West Bengal, India were selected as participants of the study where they were randomly divided into three groups of 10 each. Twelve weeks training was imparted to experimental group I (with mask), experimental group II (without mask). Group III acted as the control group. To understand the effect of hypoxic training on VO_2 max, ANCOVA was used. A significant difference was found in VO_2 max after the training among the three groups. Group I performed significantly better than without group II and group III. Group II was better than group II but poor than group I.

Keywords: VO_2 max, Elevation training musk, altitude training, physiological.

Introduction
Altitude/hypoxic training is a common and popular practice among various athletes, coaches, and sports scientists for improving exercise performance at the sea-level. The most typical altitude/hypoxic training methods proposed include living high-training high (LHTH) or living high-training low (LHTL). Recently, various living low training high (LLTH) methods such as intermittent hypoxic training (IHT), repeated sprint training in hypoxia (RSH), and resistance training in hypoxia (RTH) has become an increasingly popular altitude/hypoxic practice, where athletes live at or near sea-level but train at 2,000 to 4,500 m simulated hypobaricor normobaric hypoxic conditions (Feriche, B., Garcia-Ramos *et al*., 2014) [4, 10].
Among the various LLTH altitude/hypoxic training methods, IHT may be of interest to athletes and coaches because this training method commonly involves shorter hypoxic exposure time and duration. Such hypoxic exposure typically last < 3 hours, two to five times per week, for 2 to 6 weeks (McLean *et al*., 2014). Theoretically, the stress from hypobaric or normobaric hypoxic exposure, in addition to the training stress, will compound the training adaptations experienced with normal aerobic training and will lead to greater improvements in aerobic exercise capacity (Czuba *et al*., 2011) [3, 12]. IHT may trigger various biochemical and structural changes in skeletal and cardiac muscles that favor oxidative process; that is, IHT may enhance erythropoietic, metabolic, and haemodynamic functions, which results in the stimulation of serum erythropoietin synthesis, elevated red blood cell volume, improved exercise economy, increased blood flow, and thus enhances oxygen transporting and utilizing capacity of the blood (Czuba *et al*., 2011; Geiser *et al*., 2001; Hamlin *et al*., 2010) [3, 12, 11]. However, the efficiency of IHT for the enhancement of aerobic exercise capacity in various athletes at sea-level is controversial. Several studies reported improved aerobic exercise capacity by enhanced oxygen transporting or utilizing capacity of the blood after IHT (Czuba *et al*., 2011; Ponsot *et al*., 2006) [3, 12].
Another tool used to stimulate increased exercise performance is Elevation training mask. The Elevation training mask (ETM), also known as an altitude mask or ventilator training mask, claims to enhance athletic performance by increasing endurance and VO_2 max; in addition to improving lung function.

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The ETM is also said to simulate altitude and to induce a normobaric hypoxic condition. The ETM provides adjustable resistances during inspiration with a set resistance on expiration in order to simulate high-altitude training (between 914m to 5,486m). The design of the mask restricts the oxygen flow using flux valves that limit the amount of air entering the mask, and therefore, the lungs. Furthermore, The Elevation Training Mask 2.0 is a proven tool for simulating the effects of training in high-altitude environments. Byadjusting the mask's intake valves with the addition of the included air restriction caps, you can quickly customize the intensity setting from a 3,000' elevation (4-hole caps) up to 6,000' (2-hole caps) and 9,000' (1-hole caps)

While the Training Mask is a great way to prepare for high altitude sports and climbing, it's also beneficial to just about any type of athlete from any discipline. Training with the mask can:

- Condition the lungs by creating pulmonary resistance
- Strengthen the diaphragm
- Increase surface area and elasticity in alveoli
- Increase lung capacity
- Increase anaerobic thresholds
- Decrease workout time

The Elevation Training Mask 2.0, including clinical tests by the Northern Alberta Institute of Technology and studies by the American Council on Exercise. The central scientific principle is "Diaphragm Resistance Technology." This effectively means that the mask promotes increased lung capacity by forcing you to inhale fuller deeper breaths as you train. When your body adapts to the resistance, your lungs begin to transport oxygen more efficiently. Long term result: improved lung and diaphragm strength and increased stamina. Increases strength and power (anaerobic performance) (James P Morton, Nigel T Cable, 2005 [13].

The study attempted to investigate the effect of hypoxic training with Elevation training mask on VO_2 max of physically fit individuals.

Methods and Materials

Selection of subjects: The participants of the study were chosen from Baraboni club of Asansol, West Bengal, India. The age of subjects were ranged between 17 to 22 years. They were randomly divided into three groups of 10 each. Group I acted as Experimental group (with mask), Group II acted as Experimental group II (without elevation training mask) and group III acted as the Control group.

Selection of variables: VO_2 max was the dependent variable and Twelve Weeks of Training programme with the help elevation training mask 2.0 was the independent variable.

Criterion Measures: VO_2 max was determined in ml/kg/min

Experimental Design: Pretest–Posttest Randomized-Groups Design was used as design of the study.

Administration of the Tests and Collection of Data: Pre-tests were conducted on all the experimental and control groups. Coopers 12 minute run/ walk test was conducted to assess VO_2 max of the participants.

Statistical Technique: To find out the effects of Intermittent Hypoxic training on selected physiological variables and hematological variables Analysis of covariance (ANCOVA) was used for interpreting the results as recommended by Clarke and Clarke, 1984.The data were analyzed with the computer using SPSS (11.5) statistical package. The level of significance was chosen at 0.05.

Results

Table 1: Descriptive statistics of VO_2 max among two Experimental groups and Control group

Mean	Experimental		Control Group	SS		df	MSS	F-Ratio
	Group-I (Mask)	Group-II (Without Mask)						
Pre-test	55.3720	54.5720	54.1720	A	7.467	2	3.733	2.110
				W	47.766	27	1.769	
Post-test	57.9720	55.8720	53.7720	A	88.200	2	44.100	43.415*
				W	27.426	27	1.016	
Adjust post test	57.579	55.951	54.086	A	53.261	2	26.631	63.868*
				W	10.841	26	.417	

*. The mean difference is significant at the 0.05 level.

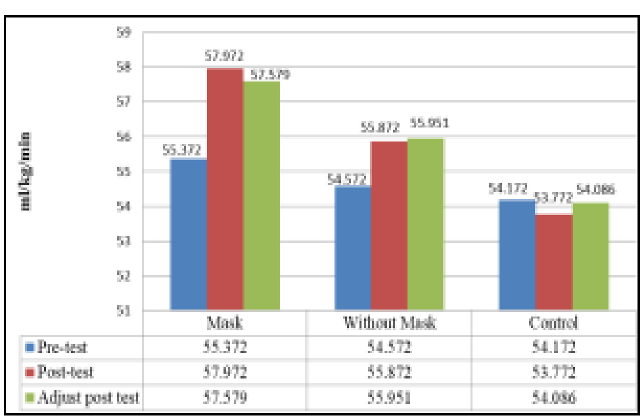

Fig 1: Graphical representation of VO2 max among two Experimental groups and one Control group

To identify the significant difference in VO_2 max among the groups ANCOVA for pre-test, post-test and adjusted posttest was applied. The obtained 'F' ratio for the pre-test was 2.110. It was found to be lower than the required F ratio of 3.35 for the degrees of freedom 2 and 27. Hence, it was inferred that the mean difference among three groups at pre-test on VO_2 max was statistically insignificant at 0.05 level of confidence.
In the post-test data analysis, the 'F' ratio was applied to test the significance of mean differences among the Mask Group, Without Mask group, and CG group on VO_2 max. The obtained 'F' ratio for the post-test was 43.415. The 'F' ratio needed for the significant differences on the mean, for degrees of freedom 2 and 27 was 3.35 at 0.05 level of confidence. Since the observed 'F' ratio on this variable was higher than the table value of 3.35, the mean differences among three groups at post-test of VO_2 max was statistically significant.
In the adjusted post-test data analysis, the 'F' ratio was applied to test the significance of mean differences among the Mask Group, Without Mask group, and CG group on VO_2 max. The obtained 'F' ratio was 63.868. Since the observed 'F' ratio was greater than the required table value of 3.37 for degrees of freedom 2 and 26 at 0.05 level of confidence, it was concluded that the performance of VO_2 max was significantly influenced by the treatments used in this study.

Table 2: Paired adjusted mean differences among two experimental group and one control group

Experimental group		Control Group	Mean difference	Critical difference
Group-I	Group-II	Group-C		
Mask group	Without mask group			
57.579	55.951		1.628*	
	55.951	54.086	1.865*	0.5935
57.579		54.086	3.493*	

Table 2 shows that there is a significant difference between all the three combinations i.e. between mask group and without mask group, between without mask group and control group, between mask group and Control Group. The mean values indicate that the mask group was the best among these three groups in terms of VO_2 max.

Discussion and Conclusion

Results indicate significant differences exist in VO_2 max among the groups. Since, the analysis of variance for VO_2 max in different groups was found significant, post hoc test was conducted to compare means of groups. As, the groups were of equal sample size, LSD test was used as post hoc. It was found that there was a significant difference between all the possible combinations i.e. between Mask group and without mask group, between Mask group and control group, between without Mask group and control group.
This indicates that both the experimental groups were significantly better than the control group. And Mask group was significantly better without mask group. The previous research works conducted with Elevation Training Mask (ETM) shows some contradictory findings. Siebenmann and Christoph Andreas (2012) At 4,559 meters altitude pulmonary vasodilation induced by the glucocorticoid Dexamethasone that elevates VO_2 max of individuals. Bryanne (2019) [15] found that VO_2 max was significantly improved in participants training with Elevation Training Mask than control group. There were some studies those found no effect of ETM in VO_2 max such as Brian (2017) and Matthew & Michael (2016) [16], though Matthew & Michael (2016) [16] discovered a slight, but not significant, increase in measured VO_2 peak and % VO_2 peak at anaerobic threshold.
In studies that intermittent hypoxic training (IHT), in most of the studies VO_2 max improved significantly (Milosz Czuba, 2019; Morton and Cable, 2005; Truijens, 2003) [17, 13]. The Group-'A', training with mask is considered to be best in improving VO_2 max The results of the present study are also supported by Moscatelli, F (2020) *et al*. study. They did the study on "Effects of twelve weeks' aerobic training on motor cortex excitability". The finding of the study was significantly increase on G, RMT (resting motor threshold) and MPAI (motor evoked potential amplitude).

Conclusion

The study reveals that there is a difference in VO2 max among the groups. The results also illustrated that the improvement in performance using hypoxic training with elevation training mask was the highest.

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To whom it may concern

I hereby certify that Mr. Sourav Ganguly, a Ph.D. scholar at Jadavpur University, conducted training for 20 students in intermittent hypoxic training for eight weeks under my supervision and guidance.

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