THE EFFECT OF MOBILE ALTITUDE DEVICE ON CARDIOPALMUNORY AND METABOLIC FUNCTION DURING HIIT AMONG TRAINED SOCCER PLAYERS

GANESAN A/L ARUMUGAM

SULTAN IDRIS EDUCATION UNIVERSITY

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GANESAN A/L ARUMUGAM

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DR. NORHAZIRA BINTI ABDUL RAHIM
PENSYARAH KANAN
FAKULTI SAINS SUKAN DAN KEJURULATIHAN
UNIVERSITI PENDIDIKAN SULTAN IDRIS
35900 TANJONG MALIM, PERAK

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FAKULTI SAINS SUKAN DAN KEJURULATIHAN
UNIVERSITI PENDIDIKAN SULTAN IDRIS
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ABSTRACT

The aim of the study is to identify the effects of Mobile Altitude Device on Cardiopulmonary and Metabolic function during High Intensity Interval Training among Trained Soccer Players.A quantitative true experimental research design was selected to answer six objective and hypothesis.There parameters were tested in the study,Maximal Oxygen Consumption(VO_2 max),Haemoglobin level (HB) and Heart Rate Variability (HRV).Thirty (n=30) trained soccer players were chosen as a sample by using non-random convenience sampling.Data analysis using one-way ANOVA series using the software programme Statistical Package for the Social Sciences (SPSS).The result showed a significant difference in the effect of HIIT on VO_2 max (P-0.003) and HRV(P-0.009) in the pre-test and post-test Trained Soccer Players,with no significant difference in the effect on HB (P-0.157).Furthermore,this study found that there is a significant effect of HIIT using MAD on cardiopulmonary and metabolic function among Trained Soccer Players.Moreover the analysis demonstrates that the control group(s) showed minimal improvement over training period, while the HIIT group(H) exhibited good improvement and the HIIT+MAD group (HE) portrayed excellent improvement throughout training and testing.The implication of the study,HIIT known to significantly enhance aerobic capacity and cardiovascular function.While Mobile Altitude Device (MAD),is significant towards the metabolic function,this combo gives a alternative way of altitude training, in oder to uncertain weather in Malaysia and difficulty of altitude accessible, MAD will be a device for indoor use as a novelty of the research. However a further investigation should be riveted into longitudinal studies, age-specific investigations, monitoring technologies, combination training methods, alternative training devices and translation to other sports.

KESAN PERANTI ALTITUD MUDAH ALIH TERHADAP FUNGSI KARDIOPULMONARI DAN METABOLIK SEMASA LATIHAN SENAMAN PENDEK INTENSITI TINGGI DALAM KALANGAN PEMAIN BOLA SEPAK TERLATIH.

ABSTRAK

Matlamat kajian adalah untuk mengenal pasti kesan Peranti Altitud Mudah Alih terhadap fungsi Kardiopulmonari dan Metabolik semasa Latihan Senaman pendek Intensiti Tinggi di kalangan Pemain Bola Sepak Terlatih. Reka bentuk penyelidikan eksperimen benar kuantitatif telah dipilih untuk menjawab enam objektif dan hipotesis. Terdapat parameter yang telah diuji dalam kajian, Penggunaan Oksigen Maksimum (VO_2 max), Tahap Haemoglobin (HB) dan Kebolehubahan Kadar Jantung (HRV). Tiga puluh (n=30) pemain bola sepak terlatih telah dipilih sebagai sampel dengan menggunakan pensampelan kemudahan bukan rawak. Analisis data menggunakan satu-cara siri ANOVA menggunakan program perisian Statistical Package for the Social Sciences (SPSS). Hasil kajian menunjukkan perbezaan yang signifikan dalam kesan HIIT terhadap VO2 max (P-0.003) dan HRV(P-0.009) dalam ujian pra dan pos. -uji Pemain Bola Sepak Terlatih, tanpa perbezaan yang signifikan dalam kesan ke atas HB (P-0.157). Tambahan pula, kajian ini mendapati terdapat kesan signifikan HIIT menggunakan MAD terhadap fungsi kardiopulmonari dan metabolik dalam kalangan Pemain Bola Sepak Terlatih. Selain itu, analisis menunjukkan bahawa kumpulan kawalan menunjukkan peningkatan yang minimum sepanjang tempoh latihan, manakala kumpulan HIIT (H) menunjukkan peningkatan yang baik dan kumpulan HIIT+MAD (HE) menunjukkan peningkatan yang sangat baik sepanjang latihan dan ujian. Implikasi kajian, HIIT diketahui meningkatkan kapasiti aerobik dan fungsi kardiovaskular dengan ketara. Walaupun Peranti Ketinggian Mudah Alih (MAD), adalah penting terhadap fungsi metabolik, kombo ini memberikan cara alternatif latihan ketinggian, berikutan cuaca tidak menentu di Malaysia dan kesukaran akses ketinggian, MAD akan menjadi peranti untuk kegunaan dalaman sebagai kebaharuan penyelidikan. Walau bagaimanapun, penyiasatan lanjut harus disambungkan ke dalam kajian membujur, penyiasatan khusus umur, teknologi pemantauan, kaedah latihan gabungan, peranti latihan alternatif dan terjemahan kepada sukan lain.

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LIST OF ABBREVIATIONS

ATM	Atmosphere
BMI	Body Mass Index
HB	Haemoglobin
HG	Mercury
HIIT	High-Intensity Interval Training
HRV	Heart Rate Variability
IHT	Intermittent Hypoxic Training
KPA	Kilo Pascals
LHTH	Live High Train High
LHTL	Live High Train Low
MAD	Mobile Altitude Device
MB	Milibars
PO2	Partial Pressure of Oxygen
RBC	Red Blood Cell
Vo2	Maximal Oxygen Consumption

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Sports physiology plays a pivotal role in sports science, particularly within the context of exercise physiology, where its principles are applied to train athletes and enhance their performance in specific sports. The focus of exercise and sports physiology is about improving performance by understanding how the body functions during exercise and using scientific principles to enable more effective training, better performance, and expedited recovery.

According to Betts et al. (2013) the cardiovascular system is a closed network to the heart and blood vessels. It pumps blood through a closed system of blood vessels, allowing for the circulation of blood throughout the body. Arteries are usually red in appearance because of their oxygen-rich content, and carry blood away from the heart

to the capillaries within the tissues. On the other hand, veins, usually appearing blue, carry blood with lower oxygen levels back to the heart from the capillaries. Capillaries, being the smallest vessels, facilitate gas exchange within the tissues. The function of the cardiovascular system is to deliver oxygen and nutrients to the body tissues, while removing carbon dioxide and waste products. The vital importance of the heart is obvious if one considers an average contraction rate of 75 contractions per minute.

Besides the cardiovascular, the respiratory system functions when blood flows from the right atrium to the right ventricle, where it is pumped into the pulmonary circuit. The blood in the pulmonary artery branches is low in oxygen but relatively high in carbon dioxide. Meanwhile, gas exchange occurs in the pulmonary capillaries (oxygen into the blood, carbon dioxide out), and blood high in oxygen and low in carbon dioxide is returned to the left atrium. From here, blood enters the left ventricle, which pumps it into the systemic circuit. Following the exchange in the systemic capillaries (oxygen and nutrients out of the capillaries and carbon dioxide and waste in), blood returns to the right atrium, and the cycle is repeated (Betts et al., 2016).

Altitude training is a specialised training method that involves living and exercising at high altitudes to improve athletic performance and induce specific physiological adaptations. The physiological responses triggered by reduced oxygen availability at high altitudes have been extensively studied, with the latest research from 2018 to 2020 providing valuable insights into the benefits and potential drawbacks of altitude training.

On the other hand, generally, altitude refers to the height of a place above sea level, whereby it can also be defined as a place or area of height. In the context of this study, altitude refers to high areas used by athletes for adjustment or training purposes, employing either traditional or contemporary altitude training methods to obtain the effects associated with high altitudes. The concept of altitude training is based on the effects of the natural response of somebody's physiological systems that try to adapt naturally to a more stressful hypoxia environment.

To be more detailed, altitude can be categorised into three regions; 1) High altitude, 1500 - 3500 meters (4,900 –11,500ft), 2) Very high altitude, 3500 - 5500 meters (11,500 – 18,000ft) and Extreme altitude above 5500 meters (18,000ft above). The higher the place, the lower the air pressure, and the oxygen available is getting 'thinner'. As a result, some physiological systems of the body will need to exert additional effort to secure an adequate oxygen supply. However, various of several physiological systems in our body can adapt to the low 'availability' of oxygen through a process known as acclimatisation or adaptation. This adaptation requires a person to spend several days or weeks staying or sleeping at altitude. This means that a person who is at altitude must inhale a larger volume of air to obtain the same number of molecules for each inhalation at sea level. The main factor influencing this situation is the low partial pressure of oxygen (PO_2), which in turn will affect the process of oxygen transport while inhaling air directly through the nose and mouth until it reaches the tissues of the body.

Generally, partial oxygen pressure refers to the combination of ambient air pressure and oxygen concentration during inhalation. For example, while at sea level,

the oxygen concentration is 20.93 or 21% and the barometer pressure (air pressure) is 760 mmHg. This indicates that the partial oxygen pressure is approximately 149 mmHg. This quantitative can be understood through the following equations: (PO_2) = (760 mmHg - 47 mmHg) x 0.2093 = 149 mmHg. The equation explains that when the air pressure at sea level is 760 mmHg, the water vapour pressure value in the lungs is 47 mmHg, and the oxygen concentration at sea level is 0.2093 (Wilber, 2004).

If viewed from a different angle, after the Olympic Games in 1968, numerous coaches and researchers turned their focus towards understanding the impact of high-altitude stimulation on performance (Balke et al., 1965). Since then, the researchers have sought to use strategies such as sea-level training and resting at altitude to obtain the benefits of this methodology (Roberts et al., 2003). Ever since there is empirical research on altitude training, which involves living or training at high altitudes for many weeks, it has been practiced by athletes to improve their abilities both at sea level and altitude (Álvarez-Herms et al., 2014) ;(de Paula et al., 2012).

Therefore, altitude training improves maximal aerobic power (VO_2 max) and athletes' performance. As altitude increases, atmospheric pressure decreases, and although the fractional concentration of oxygen remains the same (20.9%), the partial pressure of oxygen decreases, reducing the amount of oxygen available for delivery to exercising tissues. When exposed to this environment, the natural response of the human body is to breathe faster and deeper. This occurs because at high altitudes, the amount of oxygen reaching the lungs is lower compared to sea level. In other words, the reduced oxygen levels hinder the delivery and diffusion of oxygen into the bloodstream, compromising its availability to meet our metabolic necessities.

As a result of the process of acclimatisation to high altitude, the amount of Haemoglobin level in the blood increases, enabling a greater blood capacity for delivering oxygen to the tissues. One of the major benefits of altitude training is that exposure to hypoxic conditions stimulates the kidneys to produce erythropoietin (EPO), which increases red blood cell (RBC) production. Simply put, at high altitudes, the concentration of oxygen in the air is lower, leading to hypoxia. As a compensatory response, the kidneys release the hormone EPO, stimulating the production of red blood cells. The higher red blood cell count improves oxygen-carrying capacity, enhancing the body's ability to deliver oxygen to muscles during exercise (Gough et al., 2018).

The RBC circulation increases the oxygen-carrying capacity of the blood which has been correlated with improvements of VO_2 max. These various physiological adaptations occur when living and training in a hypoxic environment, where it extremely decreases the uptake of oxygen (Warren et al., 2017). Other implication, such as hypoxia, triggers angiogenesis, fostering the growth of new capillaries around muscle fibers. This process enhances oxygen delivery to the muscles, improving endurance and exercise performance (Horiuchi et al., 2020).

Research has shown that altitude training stimulates mitochondrial biogenesis, increasing the number and function of mitochondria in muscle cells. This process enhances aerobic energy production, contributing to improved endurance and performance (Li et al., 2018). However, altitude training has been linked to changes in muscle fiber composition. Slow-twitch (Type I) fibers, which are more efficient in endurance activities, tend to increase, providing an advantage for endurance athletes (Rodriguez et al., 2019).

To optimise altitude training, intermittent hypoxic exposure has emerged as a popular approach. In this method, athletes live at high altitudes but conduct their training sessions at lower elevations. This strategy allows athletes to benefit from the physiological adaptations induced by altitude while reducing the challenges associated with continuous high-altitude training (Brocherie, 2018).

In addition, proper periodisation is essential in altitude training. Athletes may spend specific periods at high altitudes during their base or preparatory phase to build physiological adaptations. They then return to sea level for more intense training during the competition phase (Cho, 2022). In another way, altitude endurance has long been a well-established practice and technique, gaining significance in fitness systems, and for practice at both altitude and sea level. Besides that, it is widely supported by elite athletes, coaches, and sports federations (Lundby et al., 2012).

Even though, there are challenges in altitude training. One of the main concerns with altitude training is the potential for detraining when athletes return to sea level. The adaptations acquired at high altitudes can diminish over time if not maintained through regular training (Mujika, 2019). In the meantime, altitude sickness can occur when individuals ascend to high altitudes too quickly. It can range from mild symptoms like headaches and dizziness to severe conditions such as pulmonary edema and cerebral edema, which can be life-threatening. Proper acclimatisation is crucial to reduce the risk of altitude sickness during training at high elevations (Fabries, 2022).

In conclusion, Altitude training remains a valuable tool for athletes seeking to enhance their performance and physiological adaptations. From increased red blood cell production to changes in muscle fiber composition and enhanced mitochondrial biogenesis, the latest research from 2018 to 2020 provides a comprehensive understanding of the benefits of altitude training. However, careful planning, such as intermittent hypoxic exposure and periodisation, is necessary to optimise the effectiveness and safety of altitude training. By addressing the challenges of detraining and altitude sickness, athletes can harness the full potential of altitude training to gain a competitive edge in their respective sports.

The conceptual benefits are categorised into gradual effects on persistent hypoxia (low oxygen supply) and serious hypoxia-related training effects of physiological processes (Rodríguez et al., 2015). Moreover, the advantages of hypoxic training are well reported in the literature and this type of training is known to affect multiple body systems, including the nervous system, endurance-respiratory, and muscle function (Hamlin et al., 2010).

Therefore, to gain a competitive edge, athletes and coaches are continuously looking for ways to improve performance. However, training at high altitudes or using a normobaric hypoxia strategy is not easily accessible. In an effort to enhance accessibility to altitude training, other methods for simulating hypoxic training have been develop over the last few years. Recent studies, such as those conducted by Porcari et al. (2016) have highlighted that the Mobile Altitude Device (MAD) was invented as a respiratory resistance training device. The MAD claims to enhance cardiovascular fitness, increase oxygen uptake (VO_2 max), as well as improve lung function.

The use of this mask is assumed to be to reduce partial oxygen pressure during exercise, creating hypoxic conditions purportedly akin to simulating high-altitude training (Biggs et al., 2017). The MAD device comes in various sizes of openings and flow valves that can be adjusted to limit the amount of air entering the mask (Danford, 2015). The use of the mask to reduce oxygen partial pressure while exercising is expected to cause the user to simulate high altitude exercise hypoxic status.

In addition, the current trend combines altitude training and High-Intensity Interval Training (HIIT), both of which have demonstrated significant effects. Notably, HIIT was recently ranked as the most popular training method, according to the annual report Global Trends in Fitness in 2018 (Thompson, 2019). It has been popularly used as an alternative to conventional endurance training which has been shown the result in higher levels of endurance performance (Laursen et al., 2002). Moreover, compared to conventional aerobic exercise or Moderate-Intensity Continuous Exercise (MICE), HIIT can produce similar and even higher changes in physiological and physical performance and associated health outcomes, but with a consistent reduction in exercise duration and volume (Burgomaster et al., 2008).

A few findings have shown the efficacy of HIIT on VO_2 max in athletes (Slettaløkken et al., 2014); (Boutcher et al., 2013), healthy lifestyle, and overweight among the non-athletes (Tjønna et al., 2013), even for cardiac patients (Koufaki et al., 2014). Even more, HIIT treatments have emerged as a time-efficient way to improve VO_2 max for adults in just two weeks (Whyte et al., 2010). Therefore, this is a preferred way to maintain adults' fitness levels due to the world that is increasingly busy in their

respective fields of work. For the most part, findings have also shown the possibility of HIIT to enhance VO_2 max or maintain health (Martin et al., 2019).

According to Bartlett et al. (2011), HIIT is an effective exercise method known to improve both aerobic and anaerobic capacity. However, the specific information regarding the optimal distance or duration required for the exercise is not provided. It is imporant to identify the type of HIIT exercise that gives the most benefits. Furthermore, HIIT is a popular training modality described as a time-efficient model that produces the same or more superior cardiopulmonary benefits as endurance exercise (Gibala et al., 2012).

From another perspective, HIIT training in the field of hypoxia is considered better than other training modes (e.g., intermittent hypoxic exposure during rest) (Millet et al., 2010). Comparable to altitude workouts, approaches such as Live Low Train High (LLTH) are employed, wherein athletes train in hypoxic hypobaric conditions and rest in normal and normal-baric conditions (McLean et al., 2014). While there are other altitude training methods, such as Live High Train Low (LHTL) and High Level Live Train (HLLT), they are all aimed at using reduced oxygen partial pressure (ppO_2) to improve the physiological changes seen during aerobic strength training.

From another angle, many athletes will find it difficult to include altitude training in their training programme. The reasons are simulated hypobaric chambers or the constraints of costs, time, and journey associated with real moderate to high-altitude environments. The best way an athlete would have to remain at moderate to high elevations for two to three weeks to gain the advantages of hypoxic training (Robertson

et al., 2010). However, because this is not always possible, some techniques can be used to simulate the LLTH hypoxic exposure protocol, such as hypoxia tents and the more recent development of the MAD.

On the whole, although altitude training methods have been proven to help improve the performance of athletes, many factors need to be considered such as the effect of the physiological and physical responses of the athletes involved and, traveling to altitude that can be financially demanding and beyond the resources of most individuals (Levine, 2002). In an effort to make altitude training more accessible, various techniques and products have been created such as nitrogen houses, hypoxia tents, and elevation masks. All these methods aim to stimulate a hypoxic environment. (Levine, 2002). This is because researchers' findings often vary, even when conducting the same study, it is crucial for a researcher to provide justification to Malaysian coaches and athletes regarding the physiological effects of MADs. These masks serve as an alternative approach to altitude training, especially when combined with HIIT, targeting improvements in cardiopulmonary and metabolic functions.

1.2 Background of Study

The relationship between altitude and humanity began to gain attention from researchers since the success of Edmund Hillary and Tenzing Norgay as the first humans to conquer Mount Everest with an altitude of 8848 m above sea level, with the addition of extra oxygen in 1953. The next idea was sparked by several researchers, sports scientists, and coaches to study the effect of altitude on athlete performance after

the 1968 Olympic Games in Mexico City, situated at an altitude of approximately 2300 meters (Wilber, 2004). A total of 17 new world records were created during the games. Despite these achievements, it is not widely known among Malaysians that one of the athletes who participated in the 1968 Mexico Olympics was the national athlete Datuk Dr. Manikavasagam Jegathesan, better known as M. Jegathesan. He set a new national record in the 200m event, clocking an impressive time of 20.92 seconds. Remarkably, this record still remains as a historical benchmark in Malaysian athletics to this day. (http://www.arkib.gov.my/web/guest/420)

Although the success factor of an athlete depends on the training programme planned by the coach, altitude and hypoxia exposure is one of the training methods that can be used as an alternative to various existing training approaches. This training regime has been widely used over the past forty years and has proven to be one to four percent improvement in athlete performance (Saunders et al., 2010). Altitude training is generally a physical training regimen conducted by manipulating the hypoxia environment or altitude, to obtain effects from hypoxia exposure through altitude acclimatisation, helping improve the physical physiological performance of athletes. This training method uses two main approaches: the traditional (classical) method and the contemporary method. The altitude training approach is traditionally implemented by staying or sleeping, and practicing at altitudes with a certain altitude level to obtain altitude exposure effects. While the contemporary approach is the altitude training regime that has been modified to two methods namely Live High Train Low (LHTL) and Live Low Train High (LLTH). Both types of training approaches are used by many coaches as an alternative training especially in helping to improve the physical

performance of their athletes and this approach is still relevant today (McLean et al., 2013).

What is the relationship of altitude to the physiology of the human body associated with the improved physical performance of an athlete? In theory, the concept of high altitude training is based on the impact of the natural reaction of several physiological systems of the body which naturally adapt to a more stressful hypoxic environment. The barometer pressure which is getting 'thin' (low) while at altitude causes the oxygen molecules needed by the body to become less efficient to be absorbed into the circulatory system before being used in the target cells. The physiological change that occurs is the secretion of the hormone erythropoietin (EPO) through the kidneys. This EPO hormone will stimulate the production of red blood cells through the bone marrow which in turn will increase the total percentage of Haemoglobin level (HB). This increase in the Haemoglobin level percentage is expected to balance the supply of necessary oxygen molecules in targeting cells and organs (Bärtsch et al., 2008).

Other physiological changes that occur are increased enzymes and excess oxygen from red blood cells used to produce energy. Apart from that lack of oxygen in the arteries will also stimulate the increase of red blood cells. The lower the air pressure, the more red blood cells are produced compared to the sea level. The resulting red blood cells, bound by Haemoglobin, are produced with the aim of increasing the oxygen content in the atrium. The heightened oxygen content in the atrial blood enables the heart to pump blood more efficiently. Subsequently, the oxygen and Haemoglobin-rich blood is transported to target cells, including muscle tissues, where it serves as a source

of energy for physical movement. If the body's natural response can be optimally exploited, it undoubtedly provides an advantage to individuals or athletes competing against opponents without this inherent advantage. Some researchers interpret this as a "cause-and-effect" relationship and consider altitude factors to have a significant impact on improving athlete performance. In other words, the effect of altitude gives`added value to the improved physical performance of untrained athletes and individuals (Wilber, 2004).

Besides altitude training, aerobic is a type of cardiovascular conditioning training. Aerobic training is usually measured by the maximum rate at which the body can utilise oxygen during maximum work. This is referred to as maximum oxygen use or VO_2 max. VO_2 max is one of the best ways of predicting cardiorespiratory endurance as well as aerobic ability. It is directly related to the cardiovascular capacity for blood supply (Howley et al., 2016). A certain type of training is needed for maintaining VO_2 max, in which the oxidative trails are activated and strengthened over time.

A recent study has shown that improvement and increase in VO_2 max can be achieved with an adequate aerobic training programme. The study also found that aerobic exercise had a significant effect on the lungs' function with an increase in breathing efficiency, as well as, a decrease in pulmonary resistance (Ferdowsi et al., 2011). Hypoxia and aerobic exercise are two separate metabolic stressors, which induce oxygen adjustment and use throughout the body. For these reasons, training under hypoxic conditions is widely used to improve the aerobic performance of athletes associated with peripheral adaptations. Over the last 20 years, several different methods and techniques have been developed to simulate hypoxia altitude or altitude training.

These include hypobaric rooms, hypoxic apartments, and hypoxic tents. The rooms are specifically designed to to induce hypoxia during both rest and exercise (Bailey et al., 2001).

Meanwhile, according to Maher (2016), the Mobile Altitude Device (MAD) stands out as the most widely used hypoxic mask, serving as an altitude simulator. It provides adjustable resistance for high altitude training during inspiration with a set expiration resistance. This design indirectly helps in building resistance in and strengthening the diaphragm. Besides that, it aids in regulating breathing, enhancing lung resistance, capacity, and oxygen efficiency, while also contributing to an overall increase in mental focus. Since the MAD has adjustable resistances, it reduces airflow which forces the athlete to inhale deeper breaths. This will promote an increased lung capacity and also adapt the athlete's body to the set resistance. This will allow the athletes' lungs to utilise oxygen more efficiently during aerobic training.

A clinical study conducted by Dreger et al. (2013) at the Northern Alberta Institute of Technology investigated the effect of the MAD on performance indicators. The study concluded that the use of the MAD while performing HIIT significantly improved cycling performance responses in males, specifically power output. The increased power output was related to the improvements in VO_2 max, which were attributed to improved pulmonary and cardiac function. The MAD was initially thought to simulate reduced atmospheric pressure and induce hemodynamic responses, mimicking the effects of training at altitude. Further examination invalidated this claim, as oxygen tension inside the MAD did not decrease at rest or with an increase in exercise workload. A 6-week cycle training study facilitated and examined the efficacy

of the MAD as an altitude simulator and observed the physiological training response compared to a non-MAD control group (Porcari et al., 2016).

A genuine acute response to altitude involves hypoxia, increased cardiac output to meet elevated oxygen demands, and an increased heart rate driven by sympathetic activity (Naeije, 2010). Although the device did not achieve hypoxic levels during rest and exercise, it led to improved aerobic capacity by enhancing the ventilatory threshold and subsequent power output at a given ventilatory threshold when compared to the control group. These findings suggest that the training mask induces similar cardiorespiratory changes as respiratory muscle trainers. Overall, based on limited research with this equipment, the MAD proves to be a beneficial training tool for increasing aerobic capacity.

On the other hand, HIIT is characterised as a model encompassing three major factors that influence aerobic endurance performance, which are maximal oxygen uptake, lactate threshold, and work economy. It is also used to check the effects of aerobic training on endurance performance. In both aerobic and anaerobic endurance sports, VO_2 max plays an important role in determining the success of the athletes. HIIT has revealed that the responses of endurance training on VO_2 max are correlated with the intensity, duration, and frequency of training. HIIT contributes to improvements in both aerobic and anaerobic fitness, thereby enhancing overall endurance performance. Moreover, HIIT has proven to be more effective than continuous steady-state running for weight loss. These repeated intense sprint bouts of short duration with recovery intervals at low-to-moderate intensity in HIITs have been considered a time-efficient method to achieve the health benefits of exercise (Foster et al., 2015).

Furthermore, HIIT is gaining popularity not only among athletes and sports enthusiasts but also among individuals seeking weight reduction. It has even been prescribed to diabetic patients as a form of exercise to help maintain blood sugar levels (Lee et al., 2020). HIITs are generating considerable interest in terms of followers and usage because of their time-saving methods and the type of exercises used in the programme (Costigan et al., 2015). HIIT is attracting significant interest in terms of followers and usage due to its time-saving methods and the types of exercises incorporated into the programme, as highlighted by Costigan et al. (2015). More athletes are using HIIT because it produces quick results compared to long steady continuous runs. HIIT is gaining widespread attention due to information gathered about the relationship between VO_2 max and repeated sprint ability. This research has revealed its effects on the recovery process, influencing game performance and the distance covered during games, as highlighted by Harrison et al. (2015).

Besides that, HIIT plays a crucial role in enhancing the technical and tactical abilities of athletes to perform well during matches, in line with the requirements and demands of the sport (Buchheit et al., 2013). Coaches emphasise the importance of increasing and maintaining physiological variables to predict performance during intermittent sports through a combination of athletic drills and maximal strength programmes. Majority of team sports use high-intensity anaerobic interval training as an important part of their training to develop maximal oxygen uptake (VO_2 max) and improve the player's ability to repeat intense exercise bouts. Previously, there was limited information about the relationship between VO_2 max and repeated sprint ability. However, recent evidence has proven that a high aerobic capacity affects the recovery kinetics during high-intensity intermittent exercise. Additionally, VO_2 max has been

shown to influence game performance and the distance covered in high-intensity running during games, as highlighted by Funch et al. (2017).

Meanwhile, HIIT not only improves the VO_2 max capacity for sports performance but also help an individual who is overweight and inactive individuals by inducing fat loss. Research has demonstrated that HIIT possesses the ability to initiate metabolic oxidation and mitochondrial enzyme activity. The group experienced a significant loss of fat relative to energy expenditure. Research has shown that the correct volume of VO_2 max can increase the activity of the mitochondrial enzymes in skeletal muscle (Barker et al., 2014). Studies have also shown that even a small workload of HIITs can induce faster metabolic adaptations. HIITs are described as repeated sessions of relatively brief intermittent exercises performed with great effort. A single attempt in a particular session of HIIT may last between a few seconds to several minutes and with multiple attempts, there will be a rest period. Selecting an optimum training programme for any specific sport or improving fitness requires knowledge of how different training intensities affect performance and physiological adaptations. One of the basic components of physical fitness is cardiovascular endurance. Lactic acid accumulation, which causes skeletal muscle fatigue, occurs because anaerobic metabolism cannot be produced at a quantitatively sufficient level compared to the energy expended (Halson, 2014).

There is limited research concerning the aerobic benefits of altitude training at sea level using an MAD in combination with HIIT and its influence on health, cardiorespiratory, and metabolic. The outcome of this study is to uncover new findings

that can inspire ideas and provide additional alternatives to athletes and coaches, particularly in developing and planning training programmes more effectively.

1.3 Problem Statement

In the past decade, there has been rapid development in research on altitude training and High-Intensity Interval Training (HIIT). The concept of altitude training is based on the effects of the natural response of individual's physiological systems that strive to adapt naturally to a more stressful hypoxia environment. Altitude can be categorised into three regions; 1) High altitude,1500-3500 meters (4,900-11,500ft), 2) Very high altitude, 3500-5500 meters (11,500-18,000ft), and Extreme altitude, above 5500 meters (18,000ft above). Whereas, the HIIT method refers to workouts that involve intense intervals, during which a person's heart rate reaches at least 80% of its maximum capacity, usually lasting one to five minutes, with periods of rest or less intense exercise. With a combination of these training methods, athletes may gain benefits such as increased lung capacity, Haemoglobin level mass, red cell volume, and enhanced muscles efficiency in extracting oxygen from the blood. Surprisingly, this combination can also lead to the burning of a significant number of calories in a short amount of time.

Besides, Daniels et al. (1970) have conducted rigorous research on altitude training determining that its purpose is to increase the utilisation volume of VO_2 max through the escalation of red blood cell production. The physiological change the occurs is that secretion of the hormone EPO through the kidneys stimulates the production of

red blood cells through bone marrow which in turn increases the percentage of HB. On the other hand, HIIT helps to improve numerous physiological parameters such as heart rate, blood pressure, blood sugar, and VO_2 max (Daussin et al., 2008). HIIT also plays an important role in an athlete's training session by helping in the development of VO_2 max, enabling them to repeat the running sessions required by the sports during matches (Cicioni-Kolsky et al., 2013).

In Malaysia, the application of altitude training and HIIT methods is still lacking. This is due to two factors. First, the physical geography of Malaysia is divided into Peninsular Malaysia and East Malaysia where each part has its own highest peak. In Peninsular Malaysia, Mount Tahan is the highest peak which is situated in Titiwangsa Range, while in East Malaysia, Mount Kinabalu in Sabah soars up from sea level to 4.095 meters (13,435ft), earning the classification of the highest altitude in Malaysia. It is located in Borneo's Crocker Range (Phillips, 2000). The second factor is the level of knowledge among athletes, teachers, and coaches about altitude and HIIT.

Therefore, it is impractical for athletes from the Peninsular to execute altitude training considering cost and time factors. Moreover, in Malaysia, due to a lack of research and information on this field, altitude training and HIIT method have been neglected by Malaysian sports enthusiasts, despite evidence suggested by researchers on the advantages of altitude training. As a result, the researcher comes up with an alternative approach to address these issues by introducing MAD. Therefore, studies need to be conducted on the effects of using MAD devices during altitude training and HIIT at sea level among healthy adults.

1.4 Research Objective

This study aims to determine the effects of Mobile Altitude Device on Cardiopulmonary and Metabolic function during High-Intensity Interval Training (HIIT) among Trained Soccer Players. The objectives of this study are to:

1.4.1 Specific Objectives

i) To identify the effect of High-Intensity Interval Training (HIIT) on the Maximal Oxygen Consumption (VO_2 max) on the pre-test and post-test between the treatment and control groups.

ii) To identify the effect of High-Intensity Interval Training (HIIT) on the Haemoglobin level (HB) on the pre-test and post-test between the treatment and control groups.

iii) To identify the effect of High-Intensity Interval Training (HIIT) on the Heart Rate Variability (HRV) on the pre-test and post-test between the treatment and control groups.

iv) To evaluate the effect of High-Intensity Interval Training (HIIT) using an Mobile Altitude Device (MAD) on the Maximal Oxygen Consumption (VO_2 max) on the pre-test and post-test between the treatment and control groups.

v) To evaluate the effect of High-Intensity Interval Training (HIIT) using an Mobile Altitude Device (MAD) on the Haemoglobin level (HB) on the pre-test and post-test between the treatment and control groups.

vi) To evaluate the effect of High-Intensity Interval Training (HIIT) using an Mobile Altitude Device (MAD) on the Heart Rate Variability (HRV) on the pre-test and post-test between the treatment and control groups.

1.5 Research Hypothesis

Based on the problem statement and objective of this study, six hypotheses were constructed by the researcher as below:

1.5.1 There is no significant difference in the effect of High-Intensity Interval Training (HIIT) on the Maximal Oxygen Consumption (VO_2 max) on the pre-test and post-test between the treatment and control groups.

1.5.2 There is no significant difference in the effect of High-Intensity Interval Training (HIIT) on the Haemoglobin level (HB) on the pre-test and post-test between the treatment and control groups.

1.5.3 There is no significant difference in the effect of High-Intensity Interval Training (HIIT) on the Heart Rate Variability (HRV) on the pre-test and post-test between the treatment and control groups.

1.5.4 There is no significant difference in the effect of High-Intensity Interval Training (HIIT) using a Mobile Altitude Device (MAD) on the Maximal Oxygen Consumption (VO_2 max) on the pre-test and post-test between the treatment and control groups.

1.5.5 There is no significant difference in the effect of High-Intensity Interval Training (HIIT) using a Mobile Altitude Device (MAD) on the Haemoglobin

level (HB) on the pre-test and post-test between the treatment and control groups.

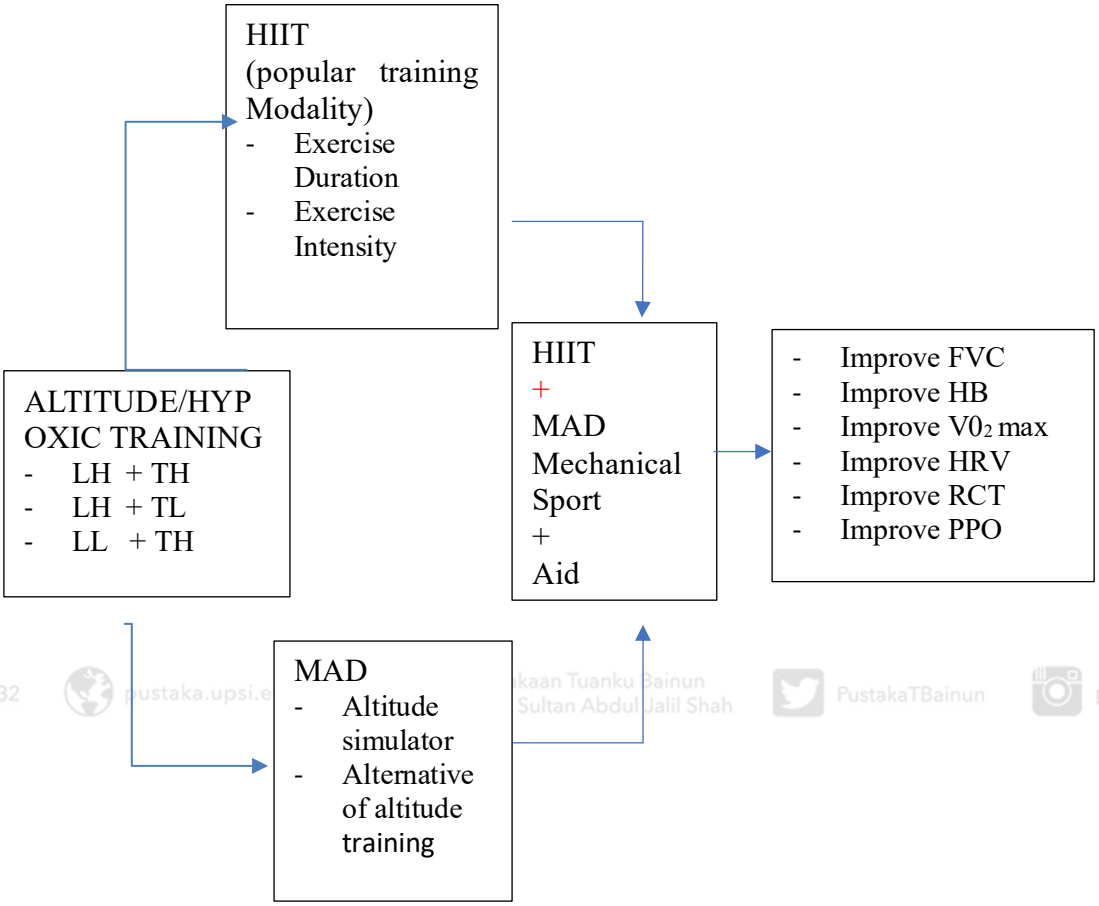
1.5.6 There is no significant difference in the effect of High-Intensity Interval Training (HIIT) using a Mobile Altitude Device (MAD) on the Heart Rate Variability (HRV) on the pre-test and post-test between the treatment and control groups.

1.6 Conceptual Framework

The conceptual framework of this study is the structure that describes the implementation of this study. It explains the relationships between independent and dependent variables.

Figure 1.1

Conceptual Framework



1.7 Operational Definition

In conducting this research, various terminologies are used in the context of exercise physiology, high-intensity interval training, altitude training methods and techniques, Mobile Altitude Device, procedures, and implementation of blood sample tests and physical performance tests. The meaning of these terminologies will be explained further based on their general definitions and relevance to the objectives of this study. Thus, several identified terminologies include:

1.7.1 Altitude

Generally, altitude refers to the height of a place (area) above sea level. It can also be defined as a place or area of height. In the context of this study, altitude refers to high areas used as places of adjustment or training by athletes employing the altitude training method, either traditional or contemporary, to achieve the desired altitude effect in accordance with the prescribed regimen. Altitude is often categorised into three main zones based on elevation:

Low Altitude: This refers to locations that are close to sea level, where the atmospheric pressure and oxygen levels are relatively high. Low-altitude environments are considered the normoxic baseline for most people.

Moderate Altitude: Locations at moderate altitudes range from approximately 2,000 to 3,500 meters (6,500 to 11,500 feet) above sea level. At these altitudes, oxygen availability decreases compared to sea level, and athletes may experience some degree of hypoxia (reduced oxygen) in their workouts.

High Altitude: High-altitude environments are typically situated above 3,500 meters (11,500 feet). Oxygen levels are significantly reduced at these altitudes, leading to pronounced hypoxic conditions. Training and competing at high altitudes can challenge athletes' cardiovascular and respiratory systems, triggering adaptations to cope with reduced oxygen availability.

1.7.2 High-Intensity Interval Training (HIIT)

High-Intensity Interval Training (HIIT) is a well-known and widely recognised, time-efficient training method aimed at improving cardiorespiratory and metabolic function and in turn, physical performance in athletes. It could be any type of exercise consisting of brief bursts of intense exercise followed by resting period or a low-intensity exercise. The entire HIIT workout can take 15-20 minutes, but it offers a wide range of advantages. Its brevity makes it a very practical and effective option for people who find it hard to participate in longer sessions. According to Roy (2013), HIIT consists of alternating short periods of intense exercise with recovery periods of passive or mild-intensity movement. Typically, the work intervals last from 15 seconds to 4 minutes and approach 80% to 95% of an individual's maximum heart rate. Recovery intervals are generally equal to or slightly longer than the intense work interval and consist of passive restore mild activity at 40% to 50% of the maximum heart rate. The combined work and rest interval commonly is repeated 6 to 10 times. Thus, the total HIIT exercise time ranges from 10 to 40 or more minutes depending on the actual duration of the work and rest periods.

1.7.3 Mobile Altitude Device (MAD)

Mobile Altitude Device (MAD) is a resistance training device that helps condition the lungs by creating pulmonary resistance and strengthening the diaphragm. (Porcari et al., 2016) explain that the MAD is a respiratory resistance device designed to strengthen the breathing muscles and improve breathing mechanics. Multi-patented flux valve

technology offers six levels of resistance which allow you to work on breathing power, inspiratory muscle strength, and breathing technique. The lightweight and comfortable design of MAD makes it a perfect addition to most forms of exercise from strength workouts to cardiorespiratory and metabolic functions.

1.7.4 Metabolic Responses

Metabolism is the process through which your body uses or produces energy from the food you eat. Chemicals in your digestive system break the food parts down into sugars and acids, as your body's fuel. Your body can use this fuel right away, or it can store the energy in your body tissues, such as your liver, muscles, and body fat. Metabolism is the whole range of biochemical process that occurs within a living organism. It consists of anabolism (the buildup of substances) and catabolism (the breakdown of substances). The term metabolism is commonly used to specifically denote the breakdown of food and its transformation into energy. A metabolic response refers to any reaction by the body to a specific influence or impact. It can occur in individual cells, a gland, an organ, or within a broader process such as the cardiovascular system.

1.7.5 Maximal Oxygen Consumption (VO_2 max)

By definition, Maximal Oxygen Consumption (VO_2 max) refers to the maximal rate at which oxygen can be used by the body during maximal work. It is related directly to the maximal capacity of the heart to deliver blood to the muscles (Howley et al., 2016).

Maximal oxygen uptake is the highest VO_2 max achieved when a person is working at maximal capacity. Classically, VO_2 max reaches a plateau and does not increase further, even with an increase in external workload. Absolute values, which are typically expressed in liters per minute (L/min-1), may range from as low as 1.0 L/min-1 (or lower in patients with cardiovascular disease) up to 6 L/min-1 (or even higher in large, well-trained individuals). Since two individuals of significantly different sizes may have the same absolute VO_2 max value, VO_2 max is often normalised for body weight and expressed as mL/kg-1/min-1. This normalisation allows for between-person comparisons. Values for VO_2 max may range from a low of 10 to a high of 80 or more mL/kg-1/min-1. It represents the maximal rate at which oxygen can be used by the body during maximal work and is directly related to the maximal capacity of the heart to deliver blood to the muscles (Ferguson, 2014).

1.7.6 Haemoglobin Level

Haemoglobin level is a protein in your red blood cells that carries oxygen to your body's organs and tissues and transports carbon dioxide from your organs and tissues back to your lungs. If a Haemoglobin level test reveals that your Haemoglobin level is lower than normal, it means that you have a low red blood cell count, a condition known as anemia. Each Haemoglobin level molecule is made up of four heme groups surrounding a globin group. Heme contains iron and gives a red color to the molecule. Globin consists of two linked pairs of polypeptide chains. The development of each chain is controlled at a separate genetic locus. Changes in the amino acid sequence of these chains result in abnormal Haemoglobin levels. For example, Haemoglobin level S is

found in sickle-cell disease, a severe type of anemia in which the red cells become sickle-shaped when oxygen is in short supply. When red blood cells die, the Haemoglobin level within them is released and broken up: the iron in the Haemoglobin level is salvaged, transported to the bone marrow by a protein called transferrin, and used again in the production of new red blood cells. The remainder of the Haemoglobin level becomes a chemical called bilirubin that is excreted into the bile which is secreted into the intestine, where it gives the feces their characteristic yellow-brown colour.

1.7.7 Hypoxia

Hypoxia refers to a state in which there is reduced availability of oxygen in the body's tissues and cells due to decreased oxygen pressure in the environment. Hypoxia can occur at various altitudes where atmospheric pressure and oxygen levels are lower than those at sea level. Hypoxia challenges the body's ability to provide adequate oxygen to working muscles and tissues during exercise, which can impact an athlete's performance and physiological responses. This challenge triggers a range of adaptations as the body attempts to compensate for the reduced oxygen availability.

There are various types of hypoxia:

Hypoxic Hypoxia: This occurs when the overall oxygen pressure in the atmosphere is reduced, often at high altitudes. Athletes training or competing at elevated locations experience hypoxic hypoxia due to the decreased oxygen content in the air.

Normobaric Hypoxia: In this type of hypoxia, athletes are exposed to reduced oxygen levels while remaining at normal atmospheric pressure. This can be achieved using altitude simulation devices like hypoxic training masks or tents.

Hypobaric Hypoxia: Hypobaric hypoxia is specifically related to reduced oxygen pressure at high altitudes. The lower atmospheric pressure results in lower oxygen partial pressure, leading to hypoxic conditions.

Exercise-Induced Hypoxia: During intense exercise, localised hypoxia can occur in muscles due to increased oxygen demand that exceeds oxygen delivery. This localised hypoxia can contribute to the production of metabolites such as lactic acid, contributing to muscle fatigue.

Intermittent Hypoxic Training (IHT): This training method involves alternating between periods of hypoxia and normoxia (normal oxygen levels) during a training session. IHT aims to enhance specific adaptations to improve athletic performance.

Adaptations to hypoxia can include increased red blood cell production, improved oxygen utilisation, enhanced anaerobic capacity, changes in heart rate and stroke volume, and adjustments in breathing patterns.

1.7.8 Normobaric

Normobaric refers to a condition or environment in which the air pressure is at a normal level. In a normobaric environment, the atmospheric pressure is equivalent to the pressure at sea level, which is approximately 101.3 kilopascals (kPa) or 1 atmosphere (ATM). This term is often used in contrast to “hyperbaric” and “hypobaric” conditions, which refer to environments with higher and lower atmospheric pressures, respectively. Normobaric conditions are typical for most everyday settings and activities, reflecting the standard pressure experienced by humans at sea level. The terminology used in this study is to explain that the air pressure used is equal to the air pressure at sea level.

1.7.9 Normoxia

In the context of sports studies, “normoxia” refers to a state in which the oxygen levels within the body and the environment are at a normal level. This typically corresponds to the oxygen concentration that athletes experience at sea level, where the air contains approximately 20.9% oxygen. ormoxia serves as a reference point for studying the effects of changes in oxygen availability on athletic performance and physiological responses. Researchers may manipulate oxygen levels to create hypoxic (low oxygen) or hyperoxic (high oxygen) conditions in controlled environments for experimental purposes. Comparing the results of these conditions with the baseline normoxia allows researchers to understand how different oxygen levels impact factors like endurance, cardiovascular function, and other aspects of sports performance.

1.7.10 Hypoxic Environment

A hypoxic environment refers to an environment or condition in which the oxygen levels are reduced or lower than what is considered normal at sea level. This reduction in oxygen availability can impact an athlete's physiological responses and performance, often leading to adaptations that aim to enhance endurance and overall aerobic capacity. Hypoxic environments are commonly used in sports science for altitude training or simulated altitude training. There are two main types of hypoxic environments used in this context:

Natural Altitude Training: This involves training and living at higher elevations where oxygen levels are lower due to decreased atmospheric pressure. The reduced oxygen availability challenges the body to adapt by increasing red blood cell production and improving oxygen transport efficiency.

Simulated Altitude Training: In this approach, athletes train in artificially created low-oxygen conditions using devices like altitude tents, rooms, or hypoxic training masks. These devices reduce the oxygen concentration in the air the athlete breathes, simulating the effects of training at higher altitudes.

1.7.11 Barometer Pressure

In sports, particularly those that take place outdoors, barometric pressure can have an impact on performance, especially in activities that involve endurance or high-altitude

environments. Barometric pressure, also known as atmospheric pressure, refers to the force exerted by the weight of the air in the Earth's atmosphere. It's often measured in units like millibars (mb) or inches of mercury (inHg). It's important to note that while barometric pressure can have effects on sports performance, it's just one of many factors that can come into play. Factors like training, technique, nutrition, mental preparation, and overall health also significantly contribute to an athlete's success. Additionally, individuals may respond differently to changes in pressure, so there's no one-size-fits-all approach. Technology and tools are available to monitor barometric pressure, and coaches and athletes might use this information to make informed decisions about training, strategy, and competition in outdoor sports.

1.7.12 Hematology

Generally, hematology is a branch of medicine concerned with the study of blood, blood-forming organs, and the study of diseases related to blood components. In this study, hematology refers to the variables in the content of blood components that will be tested to identify the effects of altitude acclimatisation based on the prescribed regimen.

1.7.13 Partial Pressure of Oxygen (PO_2)

The partial pressure of oxygen (PO_2) is the pressure exerted by a particular gas in a mixture of other gases. Partial oxygen pressure is commonly used for the measurement

of oxygen in arterial blood. The normal range of partial oxygen pressure (PO_2) is between 75mmHg to 100 mmHg. If it falls below this range, it means that the individual is not getting enough oxygen. The partial pressure of oxygen is affected by the altitude of a place, the higher the place, the lower the partial pressure of oxygen, consequently affecting the amount of oxygen that enters the bloodstream. Therefore, the partial oxygen pressure in this study is associated with a lack of oxygen below normal levels in the atrial blood, which in turn will affect the delivery of oxygen to the muscles and target cells.

1.7.14 Hematological Examination

Referring to the blood sample collection and testing procedures performed by the hospital medical officer, the samples are further analysed in the pathology laboratory to assess the effect of altitude adaptation on the red blood cell (RBC) and Haemoglobin (HB) components.

1.7.15 Anthropometry Test

The terminology ‘anthropometry’ is a field of knowledge concerned with the measurement of structures or parts of the human body. The term comes from Eastern Greek meaning ‘measurement’ (metric) and ‘human’ (anthro). In this study, an anthropometric test is used to measure several predetermined physical characteristics, namely height, weight, and body mass index (BMI) of the study participants.

1.7.16 Cardiovascular Endurance

In general, cardiovascular endurance refers to the ability of the heart to pump blood and supply oxygen to the entire physiological system of the body. (Corbin et al., 1998) define cardiovascular endurance as the ability of the heart, blood vessels, blood, and respiratory system to supply oxygen to muscles and the ability of muscles to use it to accommodate exercise intensity.

1.7.17 Live High Train High (LHTH)

The Live High Train High (LHTH) training method, also known as the classical (traditional) training method, is the earliest form of altitude training. Athletes who use this method will stay and train at altitude based on a pre-determined training regimen.

1.7.18 Live High Train Low (LHTL)

The Live High Train Low (LHTL) training method involves staying at an altitude (<2000 m / 6562 ft) and undergoing training at a lower altitude (<1500 m / 4921 ft) with a specific regimen.

1.8 Significance of Research

The significance of this study is to provide answers and solutions to the identified issues and research questions. Therefore, the study's focus is on expected findings, which, in turn, can contribute to enhancing the quality of national sports. Additionally, the study serves as a valuable reference for sports organisations in Malaysia. By offering insights, this study is expected to inspire and spark ideas among the country's sports activists, especially coaches and national athletes, ultimately contributing to the improvement of athlete performance in the country.

Furthermore, the significance of this study is to test the effectiveness of using an Mobile Altitude Device (MAD) during High-Intensity Interval Training (HIIT) on metabolic parameters, such as maximal oxygen consumption (VO_2 max), Haemoglobin level (HB), and heart rate variability (HRV). According to the researcher, these findings will provide additional information into the efficacy of HIIT using MAD during altitude training at sea level, which can improve cardiopulmonary fitness.

Moreover, in Malaysia, due to a lack of research and information on this field, altitude training and HIIT method have not been widely consideration by Malaysian sports enthusiasts, despite evidence suggested by researchers on the advantages of altitude training. As a result, researchers have proposed an idea to tackle these issues by exploring alternatives methods, specifically by investigating the effects of using MAD on cardiopulmonary function.

1.9 Research Limitation

1. When this work is completed, the researcher is likely to encounter various limitations in completing the analysis. These limitations stem from both internal and external factors. It involves aspects not directly monitored by the researcher, such as food intake, rest, and sleep, which are considered limitations due to their potential influence on the study. Another limitation arises from the diverse social and economic backgrounds of the study sample. The variations in their former dietary patterns and lifestyles are also regarded as constraints in this study.

2. Each participant in the study did not have the same level of physical activity. Therefore, due to their context and training status, the speed chosen to achieve a moderate to high intensity differed for each participant. Each participant in the study did not have the same level of physical activity. Consequently, due to variations in context and training status, the speed chosen. Each participant is required to engage in a specific amount of aerobic training outside the study. Given that every participant may not run at the same pace, individual strength levels are crucial for success. Furthermore, the lack of monitoring of diet and caloric intake outside the test site could potentially impact the body composition of participants.

1.10 Summary

The research aims to test the effectiveness of using a Mobile Altitude Device (MAD) during High-Intensity Interval Training (HIIT) on metabolic parameters, including Maximal Oxygen Consumption (VO_2 max), Haemoglobin level (HB), and Heart Rate Variability (HRV). Secondly, this research aims to determine if there are differences in aerobic capacity and function during a training session with or without an MAD at sea level. The researchers have found that improving cardiopulmonary endurance involves providing a well-organised HIIT training programme for eight weeks. Considering the potential variation in students' content knowledge on HIIT and MAD, this aspect needs careful consideration. The hypothesis in this chapter briefly outlines the effects of eight weeks of HIIT training using MAD on cardiopulmonary function.

Sports development in Malaysia is doing well, however, the researchers hypothesised that the outcomes of this study will contribute further improvement due to certain factors. One of the major factors identified is the insufficient emphasis on physical fitness preparation, with more focus given on the aspect of skill training in the technical and tactical aspects of the game. Therefore, assigning greater importance to physical fitness is crucial, considering it as one of the important elements in sports. Hence, fitness enhancement training programmes through systematic conditioning training must be conducted regularly to ensure that athletes maintain an optimal fitness level.

Moreover, the importance of the study lies in its potential to provide valuable findings that can contribute to improving the quality of national sports. It serves as a

reference for sports organisations in Malaysia, aiming to inspire and generate ideas among the country's sports activists, particularly coaches and national athletes in contributing to the improvement of athlete performance in the country. According to the researcher, these findings will provide additional information into the efficacy of HIIT using MAD during altitude training at sea level, potentially improving cardiopulmonary and metabolic functions.