EFFECTS OF POLARIZED TRAINING MICROCYCLE ON PHYSICAL PERFORMANCE PARAMETERS IN AMATEUR MIDDLE-DISTANCE RUNNERS

CHEN CHANGYI

Graduate School Srinakharinwirot University

2024

ผลของการฝึกแบบโพลาไรซ์รายสัปดาห์ต่อสมรรถนะทางกายในนักวิ่งระยะกลางระดับสมัครเล่น

CHEN CHANGYI

ปริญญานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตร
วิทยาศาสตรมหาบัณฑิต สาขาวิชาวิทยาศาสตร์การกีฬาและการออกกำลังกาย
คณะพลศึกษา มหาวิทยาลัยศรีนครินทรวิโรฒ
ปีการศึกษา 2567

EFFECTS OF POLARIZED TRAINING MICROCYCLE ON PHYSICAL PERFORMANCE PARAMETERS IN AMATEUR MIDDLE-DISTANCE RUNNERS

CHEN CHANGYI

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of MASTER OF SCIENCE

(Sport and Exercise Science)

Faculty of Physical Education, Srinakharinwirot University

2024

THE THESIS TITLED

EFFECTS OF POLARIZED TRAINING MICROCYCLE ON PHYSICAL PERFORMANCE PARAMETERS IN AMATEUR MIDDLE-DISTANCE RUNNERS

BY

CHEN CHANGYI

HAS BEEN APPROVED BY THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTER OF SCIENCE IN SPORT AND EXERCISE SCIENCE AT SRINAKHARINWIROT UNIVERSITY

....

(Assoc. Prof. Dr. Chatchai Ekpanyaskul, MD.)

Dean of Graduate School

....

ORAL DEFENSE COMMITTEE

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(Assoc. Prof. Dr.Sonthaya Sriramatr)	(Asst. Prof. Dr.Chanawat Sanpasitt)
.... Co-advisor	.... Committee
(Dr.Watunyou Khamros)	(Lecturer Dr.Krirkwit Phongsri)

Title	EFFECTS OF POLARIZED TRAINING MICROCYCLE ON PHYSICAL PERFORMANCE PARAMETERS IN AMATEUR MIDDLE-DISTANCE RUNNERS
Author	CHEN CHANGYI
Degree	MASTER OF SCIENCE
Academic Year	2024
Thesis Advisor	Associate Professor Dr. Sonthaya Sriramatr
Co Advisor	Dr. Watunyou Khamros

Polarized training (PT) is one type of training that could develop the performance of athletes who used endurance as their primary performance. Although PT had been widely utilized in elite endurance sports, its application in amateur populations remained underexplored. This study aimed to investigate the effects of polarized training (PT) on performance and mood among amateur middle-distance runners. Twenty-four male amateur runners were randomly assigned to either a polarized training group (PTG, n = 12) or a control group (CG, n = 12). The PTG followed a structured protocol with 80% low-intensity aerobic training (60–65% HRmax) and 20% high-intensity interval training (90–95% HRmax), distributed across training days within a microcycle, while the CG trained according to the general program. Measurements included maximal oxygen uptake (VO_2max) via the Yo-Yo IR1 test, 800 m and 1500 m time trials, and psychological status assessed by the Profile of Mood States (POMS). Both groups improved VO_2max throughout the period, and the improvements were significant ($p < 0.05$). The PTG showed higher VO_2max than the CG in the post-test (51.36 ± 1.45 mL/kg/min vs 50.63 ± 1.02 mL/kg/min) ($p < .001$). Both groups improved their 800-meter and 1500-meter trials throughout the period. For between-group comparisons, the PTG performed better than the CG in the post-test of the 800-meter time trial (PTG: 02:28.40 ± 0:9.28 vs CG: 02:36.51 ± 0:12.79) ($p = 0.013$). In terms of POMS, the PTG demonstrated significantly lower total POMS scores than the CG ($p < .005$), particularly in tension, depression, anger, vigor, self-esteem, confusion, and total mood disturbance. These findings suggested that PT was effective in enhancing aerobic fitness, event-specific performance, and moods among amateur middle-distance runners, and that coaches should consider adopting PT protocols with structured microcycles to optimize both physical and psychological outcomes.

Keyword : polarized training, amateur runners, VO_2max, psychological performance, middle distance

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to all individuals and institutions whose support and guidance made this research possible.

First of all, I would like to thank my alma mater for its cultivation of me. It allows me to study and grow here. I have gained a lot of knowledge and research methods.

I am profoundly grateful to my major advisor, Dr. Watunyou Khamros, whose dedication, patience, and academic rigor guided me through every stage of this research. His profound knowledge in sports science and relentless pursuit of excellence inspired me to push beyond my limits. Equally, I thank my co-advisor, Assoc. Prof. Dr. Sonthaya Sriramatr, for his constructive criticism, innovative ideas, and collaborative spirit, which enriched the depth and validity of this study.

I would also like to acknowledge the Oral Defense Committee, including Major-advisor Chair Dr. Watunyou Khamros and Co-advisor Assoc. Prof. Dr. Sonthaya Sriramatr, for their meticulous evaluation and constructive suggestions, which strengthened the quality of this thesis.

Special appreciation goes to the research participants—the amateur middle-distance runners from Guangxi Vocational and Technical College of Mechanics and Electricity. Their commitment, perseverance, and enthusiasm in embracing the training protocols and data collection processes were instrumental to the success of this study.

Lastly, I extend my gratitude to my family and friends for their unwavering emotional support, encouragement, and belief in my abilities. Their love and patience sustained me through the challenges of this research endeavor.

This work would not have been possible without the collective contributions of these remarkable individuals and institutions.

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CHAPTER 1

INTRODUCTION

Background

Since the 1970s, elite endurance athletes have consistently advocated for a combination of high-intensity and low-intensity training. In his book "80/20 Running," Thaler argues that polarized training, also known as "2-to-8" training, can be advantageous for endurance athletes at all levels. Numerous other sports researchers have also identified the optimal high-low intensity ratio as 2:8 in endurance training, wherein maintaining 80% low-intensity training and allocating 20% to high-intensity sessions can significantly enhance key performance indicators. In the past decade, polarized training (PT) has emerged as a widely used training method in endurance sports, particularly in middle-distance running and other endurance events. This distribution of intensity in PT significantly reduced the occurrence of the 'training dead zone,' where physiological adaptations became stagnant, maximizing the benefits of both low and high-intensity training. As a result, PT can maximize training effectiveness while minimizing the risks of overtraining (Seiler, 2010; Stöggl & Sperlich, 2015) . This approach is particularly beneficial for middle-distance running (800-1500m), which demands a combination of aerobic and anaerobic systems, requiring athletes to balance endurance and speed (Grove & Prapavessis, 1992) . In recent years, research on polarized training is not uncommon. Many scholars have tried to obtain new research conclusions through literature review, and finally found that both POL and PYR models can improve speed or power relative to the aerobic threshold. In contrast, all TID models can effectively improve speed or power relative to the anaerobic threshold (Rivera-Köfler et al., 2025) . Another group of researchers also proposed that POL is superior to other TIDs in improving VO_2peak; however, the impact of POL on other endurance performance alternatives is similar to that of other TID (Silva Oliveira et al., 2024) .

In terms of physiological mechanisms, middle-distance running and long-distance running mainly rely on the aerobic energy supply system to oxidize and decompose glucose or fat, releasing energy for muscle activity. Long-distance running has a relatively low intensity and lasts for a long time, so the aerobic energy supply system is dominant, and the body's fat metabolism is relatively active, providing a stable source of energy for exercise. Although middle-distance running also relies on aerobic energy supply, because its intensity is slightly higher than that of long-distance running, muscles also need the support of the anaerobic energy supply system at certain times to cope with short-term peaks in energy demand. So, from a physiological point of view, PT is more suitable for training middle- and long-distance runners.

Recent studies have demonstrated that PT is highly effective in enhancing both aerobic capacity and lactate clearance ability. Firstly, Low-intensity training enhances aerobic base, increases capillary density, and promotes fat oxidation, which helps delay the onset of fatigue. This has become the fundamental knowledge for exercisers after years of practical experience. Long-term adherence to low-intensity training, also known as aerobic fitness in China, is highly regarded as the preferred approach for Chinese amateur bodybuilders. Additionally, for professional athletes and some amateur athletes with competitive aspirations, high-intensity training is combined with a substantial number of low-intensity exercises to stimulate cardiovascular and cerebral vessels while increasing overall physical load intensity. Because High-intensity training maximizes cardiovascular load, thereby improving maximal oxygen uptake (VO_2 max) and lactate threshold, it enables athletes to sustain higher intensities for longer durations (Stöggl & Sperlich, 2014) . These physiological adaptations provide a strong aerobic foundation for middle-distance runners while improving lactate tolerance and anaerobic capacity, which are crucial for balancing power and endurance during competition.

In practice, the implementation of polarized training relied on two additional important parameters: training zones and training cycles. According to Tudor O. Bompa's theory, any training involves phases of physiological adaptation, maximum strength, and explosive power conversion, which together form a training cycle. Only through the combined effects of cycles and training zones can exercise achieve the intended benefits. Under the polarized training model, the impact of training cycles and training zones on training outcomes is particularly significant. This is especially true for amateur athletes, as the uncertainty in workout durations due to work and life commitments can lead to ineffective training. Without proper planning of training zones, they may exert effort without achieving the desired results. While the effectiveness of PT has been widely validated in elite athletes, there is still a lack of research on its application among amateur middle-distance runners. Most existing studies focus on elite athletes or marathon runners, with limited attention given to the long-term effects of PT microcycles (6-8 weeks) on fitness parameters. However, based on logical analysis, PT training should also have a certain effect on non-professional athletes. Scholars have also conducted similar studies on recreational runners. The results showed longitudinal comparison of running performance and changes in fitness and body composition between polarized and endurance training in recreational runners. Recreational runners achieved similar improvements in 5-km performance and fitness with POL or CFE, but the improvement in VO_2max was greater with POL (Carnes & Mahoney, 2019) . In particular, the application and research of PT among university-level athletes in China are still in their early stages. For amateur middle-distance runners, the optimal use of PT to improve aerobic capacity, lactate threshold, running economy, and performance remains underexplored.

In a study, a literature search was performed using PubMed and SPORTD discus. A total of 1836 articles were identified, and 14 relevant studies were analyzed. The findings suggest that a polarized training approach appears to be effective in enhancing VO_2max, VO_2peak, and work economy over a short-term period for endurance athletes. Specifically, a training intensity distribution involving a moderate to high volume of HIIT (15–20%) combined with a substantial volume of LIT (75–80%) appears to be the most beneficial for these improvements. It was concluded that polarized training is a beneficial approach for enhancing VO_2max, VO_2peak, and work economy in endurance athletes (Hebisz & Hebisz, 2024) .LIT training is training below the lactate threshold. During LIT training, lactate begins to accumulate in the blood faster than it can be cleared. LIT training can improve mitochondrial capacity and capillary density, thereby achieving better oxygen uptake capacity.

Therefore, investigating the effects of PT microcycles on the physical performance of amateur runners, specifically regarding VO_2 max, running economy, and perceived exertion, holds significant theoretical and practical value. The article will adopt a dual research model of qualitative and quantitative studies. Based on theoretical research and analysis of existing literature, it will explore the basic principles and operational methods of polarized training theory, building a theoretical framework through these principles. Quantitative research will be conducted by monitoring various data indicators of participants in a set cycle and conducting extensive data surveys. The research results will be analyzed using scientific algorithms. Gap by conducting a six-week PT intervention for university-level amateur middle-distance runners and systematically evaluating its impact on key performance parameters, including VO_2 max, 800-meter, and 1,500-meter tests. Additionally, the Profile mood state test was taken weekly.

By conducting this study, Find the training zone thresholds for polarized training in a microcycle environment, it is expected to provide new empirical support for the PT theoretical framework and offer more scientific training guidance for practitioners and coaches in the field of endurance sports, especially in improving the competitive performance and training outcomes of amateur athletes.

Purpose of study

1. Analyze the effects of major factors in polarized training (such as VO_2max and sports fatigue). This study aims to evaluate the effects of polarized training on the performance (VO_2max, 800m, 1500m) of middle- and high-level middle- and long-distance runners.

2. Comparative evaluation of the effects of polarized training on actual sports performance: This study aims to evaluate the effects of the sample group and the polar training group on endurance in VO_2max, 800m, 1500m performance, and psychological fatigue through actual sports performance tests, and understand its applicability in real sports environments.

The importance of studying

1. To understand the impact of Polarized Training on performance enhancement in middle-distance running

2. To evaluate the practical application of Polarized Training during the competition phase for middle-distance runners, offering data-driven guidance for optimizing training regimens and enhancing competitive outcomes. The findings can be applied to develop effective strategies that balance endurance and anaerobic power in real-world scenarios.

3. To contribute scientific evidence supporting the use of Polarized Training among amateur middle-distance runners, providing valuable insights for coaches, sports scientists, and practitioners. Disseminating these results will promote the adoption of evidence-based training methods, leading to improved athletic performance across various endurance disciplines.

Scope of the research

Populations

The population for this research includes middle-distance runners from Guangxi Vocational and Technical College of Mechanics and Electricity, who are actively training for collegiate and regional competitions. Participants are male athletes, aged 18-25, with a minimum of one year of continuous training experience in middle-distance events, such as 800m and 1500m.

Participants

A total of 24 middle-distance runners from Guangxi Vocational and Technical College of Mechanics and Electricity were selected using purposive sampling. The sample size of 24 participants was determined based on previous literature (González-Mohíno et al., 2016) , which is calculated from an effect size of 0.67 and a test power of .80.

Variables of study

The relationships between the independent variables, dependent variables, and control variables in this study are as follows.

Independent variable

Polarized Training program for middle runners, 6 weeks

Dependent variable

1. 800-meter time
2. 1500-meter time
3. Maximum Oxygen Uptake (VO_2max)
4. Profile of Mood States (POMS)

Definition of specific terms

Polarized Training (PT)

A training model that divides intensity into two distinct zones—approximately 80% of training is at low intensity (aerobic), while the remaining 20% is at high intensity (anaerobic). Polarized training is primarily used to enhance both aerobic base and high-intensity capacity (Seiler, 2010) . In this study, the definition of polarized training follows the 80:20 training principle from international training standards, while also exploring the relationship between training zones and ratios in certain amateur individuals.

Microcycle

A short-term training cycle, typically lasting a week, is designed to achieve targeted adaptations through specific training arrangements. In polarized training, microcycles are structured to vary training load systematically to optimize recovery and adaptation (Haff, 2013) . Theory and Methodology of Training. In this study, the microcycle is set to 6 weeks.

Profile of Mood States (POMS)

The Profile of Mood States (POMS) is a widely used psychological mood assessment tool in sport, health, and psychology. It measures mood or feeling levels in six main areas: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment. In this study, it was used for assessment before each training session.

Research Conceptual Framework

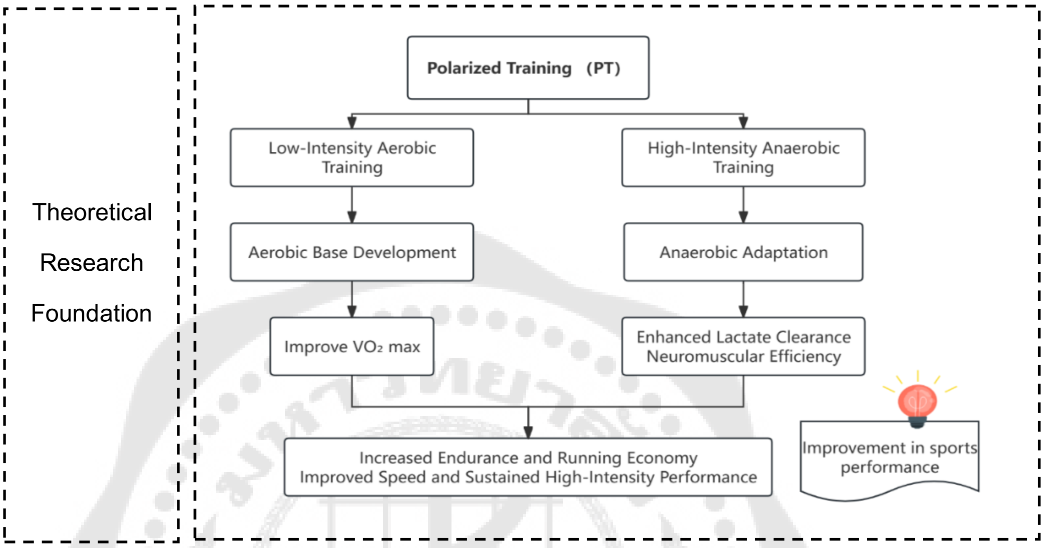

FIGURE 1 Research Conceptual Framework

Research hypothesis

1. It is expected that the data of the sample group and the polarized training group in this study will be different in terms of maximum oxygen uptake, 800m, 1500m performance, and psychological fatigue, and it will help understand and analyze the applicability of polarized training in real sports environments.

2. It is expected that the research results will significantly enhance the positive effects of polarized training on the endurance and sports performance of amateur middle- and long-distance runners. We hope that this will promote this efficient training method to a wider group.

CHAPTER 2
LITERATURE REVIEW

In this research, the researcher reviewed documents and related research, presenting the following topics:

1. Polarized Training in Endurance Sports
2. Research on the Theoretical Framework of Polarized Training
3. Factor Analysis in the Polarized Training Model
4. Mood and training outcomes in runners

Polarized Training in Endurance Sports

Theory of Polarized Training

The polarized training model was introduced in the 1990s, with representative research focusing on the training of elite rowers, cyclists, and marathon runners. This method has since been widely adopted by athletes and fitness enthusiasts to enhance endurance and improve physical performance. In polarized training, high-intensity training typically involves vigorous aerobic activities, such as prolonged fast running or high-intensity interval training (HIIT). These exercises elevate heart rate and cause muscle fatigue, promoting improvements in aerobic capacity and metabolic efficiency. On the other hand, low-intensity training consists of lighter aerobic activities, such as jogging or relaxed cycling, which help the body recover and enhance muscular endurance and rehabilitation capacity. The core idea of polarized training is to alternate between high- and low-intensity sessions to stimulate different physiological systems, thereby boosting overall athletic performance. This training method is considered more effective in improving aerobic capacity, strengthening cardiovascular function, enhancing metabolic adaptability, and reducing the risk of overtraining. In various media outlets and websites, this approach has garnered widespread attention for its proven benefits and practical application.

Polarized Training (PT) has emerged as a widely recognized training method in endurance sports, particularly suited for middle-distance runners who require a balance between aerobic endurance and anaerobic power. Polarized training is commonly referred to as the "80/20 Rule." This distribution ratio is defined based on the polarized training model proposed by Stephen Seiler in his book 80/20 Running. The distribution of training intensity characterizes PT into 80% low-intensity training (LIT) and 20% high-intensity training (HIIT). In numerous past studies, this training method has been shown to have a positive effect on improving endurance and athletic performance. For example (Carnes & Mahoney, 2019). In the past 20 years, various studies and sports practices on polarized training have not been uncommon. In two studies, (Pla et al., 2019)and(Silva Oliveira et al., 2024), a meta-analysis of previous papers proved that the POL mode has better performance than the THR and TID exercise modes. Recreational runners achieved similar improvement in 5-km performance and BC through polarized training or CFE, but POL yielded a greater increase in VO_2max. In a study of running, Carnes and Mahoney (2019) had participants (N = 21) complete 12 weeks of either CFE or polarized endurance training (POL). Both groups trained 5 days per week. The results found that recreational runners experienced greater increases in maximal oxygen uptake (VO_2max) with polarized POL training. Because of this approach aims to reduce the likelihood of adaptation plateaus and accumulated fatigue commonly associated with moderate-intensity training. Multiple research projects have also empirically demonstrated this through data. This approach reduces adaptation plateaus and accumulated fatigue, making it highly effective for endurance athletes at different levels (Seiler, 2010; Stöggl & Sperlich, 2015) . These studies all show that the polarized training mode has greater advantages than other modes in improving endurance, maximum oxygen uptake, etc.

A large number of amateur middle- and long-distance runners and marathon enthusiasts in China regard polarized training as a fundamental method to improve endurance. In this context, two issues are worth exploring: 1. Existing literature predominantly focuses on the effects of PT on elite athletes, with limited research on amateur middle-distance runners. While the effectiveness of PT in elite athletes has been widely validated, its impact on amateur middle-distance runners has been less explored. conducted a systematic review and meta-analysis on recreational runners and found that PT was superior to traditional training models in improving VO_2max, LT, and running economy. Additionally (Treff et al., 2019) . This issue will ultimately be addressed through the research in this article. 2. According to the definition of the 80:20 principle, the challenges faced by amateur long-distance runners include: What intensity qualifies as low-intensity or easy training? What intensity qualifies as high-intensity or hard training? And where are the starting and ending points for these two intensities? Answering these questions involves addressing a key factor in the values. The 80:20 zone division essentially combines the first two zones into one category. Polarized training model: the design of training zones. Training zones refer to three different stages of oxygen demand during exercise: the aerobic zone, the mixed aerobic-anaerobic zone, and the high-intensity zone. These zones are typically monitored using the lactate threshold. The physiological mechanism of polarization training of Rivera-Köfler et al. (2022) that explained

Low-intensity training

Strengthen the aerobic base and improve the efficiency of the cardiovascular system. Increase the density and function of mitochondria in muscles and improve fat oxidation capacity. Promote recovery and reduce fatigue accumulation during training

High-intensity training

Increases maximum oxygen uptake and enhances cardiopulmonary function. Increases lactate threshold and improves the ability to output at high intensity. Stimulates fast-twitch muscle fibers (Type II) and improves explosive power and speed.

TABLE 1 Polarized Training Literature Review Results

Researcher	Research purpose	Participants	Research results
(Treff et al., 2019)	Examples from the liter ature illustrating the us efulness of PI Calculati ons are discussed. As well as its limitation	Meta-analysis	Defining Polarized Training Zones and Intensities
(Stöggl & Sperlich, 2015)	Retrospective analysis of the training intensity distribution (TID) of domestic and foreign competitive athletes in different endurance events	Meta-analysis	For both trained and amateur athletes, polarized TID resulted in better responses to endurance-related variables than TID, emphasizing HVLIT or threshold training
Carnes and Mahoney (2019)	Longitudinal comparison of running performance and changes in fitness and body. The composition of Polarized and endurance training in recreational runners	Recreational runners (N=21)	Recreational runners achieved similar improvements in 5-km performance and fitness With POL or CFE, but the Improvement in VO_2max as greater with POL

TABLE 1 (Continue)

Researcher	Research purpose	Participants	Research results
(Pla et al., 2019)	Systematically search the literature to identify and analyzed data	Systematic Review and Meta-Analysis	Results suggest that POL may lead to a greater improvement in endurance sport performance than THR.
(Rivera-Köfler et al., 2025)	To analyzed the long-term effects of POL on key endurance physiological and performance-related variables and systematically compare it with other training intensity profiles.	Meta-analysis	Both the POL and PYR models increased speed or power relative to the aerobic threshold. In contrast, all TID models were effective in increasing speed or power relative to the anaerobic threshold.
(Silva Oliveira et al., 2024)	Aimed to review systematically and meta-analyzed evidence comparing POL to other TIDs on endurance performance	Systematic Review and Meta-Analysis.	POL was superior to other TIDs in increasing VO_2peak; however, the effects of POL on the remaining surrogate markers of endurance performance were similar to those of other TIDs.

Research on the Theoretical Framework of Polarized Training

As mentioned earlier, the key to polarized training lies in the concept of training zone values, which refer to the distribution ratio of training intensity during the training process. Training intensity distribution has become a research focus following studies on load structure, statistics, evaluation, and monitoring. It integrates various elements such as load monitoring, statistics, and evaluation, providing a new approach to planning, monitoring, and adjusting endurance training loads. This method is characterized by periodicity, phasing, and universality, playing a significant role in the practice of cyclical endurance sports training. The concept of training intensity distribution originated from the training practices of elite endurance athletes in countries like Germany and Norway, particularly in sports such as cross-country skiing, middle- and long-distance running, and rowing (Stöggl & Sperlich, 2014) .

The reason was that, compared to skill-dominated, non-cyclical sports such as combat and judged events, cyclical endurance sports like running, swimming, rowing, and cross-country skiing had relatively simple movement structures and easier load monitoring. This simplicity makes them more conducive to quantitative recording and analysis. As a result, research on training intensity distribution has primarily focused on these sports. According to (Seiler, 2010) , about 80% of the training was low-intensity training and about 20% was high-intensity training.

In the polarized training mode, Z is usually used to represent the training interval, which is generally divided into three stages: Z1 (zone 1) represents the low-intensity training interval, Z2 (zone 2) represents the medium-intensity training interval, and Z3 (zone 3) represents the high-intensity training interval. PI (polarization index) represents the polarized, the formula is $PI = \log10 (Z1/Z2 \times Z3*100)$, when Z2 is zero, $PI = \log10 (Z1/0.01 \times Z3-0.01 *100)$; When Z2 is zero or $Z3 > Z1$, the PI equation is not valid or does not satisfy the polarization mode. When $PI > 2$, the polarization mode can be satisfied. According to the theoretical framework of polarization, the relationship between Z should be: $Z1 > Z3 > Z2$, Z1 always occupies the largest proportion and is much higher than Z2 and Z3, $Z3$ always $> Z2$, and meets PI (Treff et al., 2019) . A study

(Burnley et al., 2022b) provided a critical critique of the current popularity of polarized training. The meta-analysis provided the necessary total training volume for individual athletes in the sport being trained and appropriately balanced the distribution of training intensity between the three zones. Additionally, the results of a study showed that a polarized training model was consistently superior to a threshold training model in improving aerobic endurance performance. The best way to implement a polarized training program may be to go easy on long, slow workouts, avoid “race pace,” and maintain tempo on intervals (Hydren & Cohen, 2015) . These studies suggest that polarized training must be phased.

The advantage of this model lies in the frequent switching between Z1 and Z3, which increases the "varying degrees" (VD) of load. This creates a clear distinction between training intensities and diversifies training forms. However, there are certain limitations. For instance, the increase in VD may lead to a higher risk of injuries. Additionally, this model requires precise heart rate monitoring equipment and strict control of load intensity proportions, making the operational procedures and statistical methods relatively complex. As a result, multiple factor analyses are often involved in the research process.

TABLE 2 Theoretical Framework of Polarized Training Literature Review Results

Researcher	Research purpose	Participants	Research results
(Treff et al., 2019)	Examples from the literature illustrating the usefulness of PI-calculation are discussed, as well as its limitations	Hypothesis and Theory Article	The PI was calculated as log10(Zone 1/Zone 2 * Zone 3 * 100), where Zones 1-3 refer to the total training volume (time or distance) of low, moderate, or high intensity training

TABLE 2 (Continue)

Researcher	Research purpose	Participants	Research results
(Seiler, 2010)	Exploring methods of endurance training through a literature review	Narrative Review	A large number of studies on PT intensity distribution show that about 80% of them are low-intensity training and about 20% are high-intensity training. For example, the maximum oxygen uptake (VO_2max) is about 90% of interval training.
(Burnley et al., 2022a)	Key criticisms of the current fashion for polarized training.	Debate Article	Provide athletes with the total training required for the program and appropriately balance the distribution of training intensity among the three zones.
(Hydren & Cohen, 2015)	Evidence for replacing these models with the proven polarized training model seems warranted	Narrative Review	POL is consistently better than threshold training for improving aerobic endurance. The best way to implement a polarized training program may be to keep it easy during long, slow workouts and avoid "race pace."

TABLE 2 (Continue)

Researcher	Research purpose	Participants	Research results
(Stöggl & Sperlich, 2014)	Explore four training philosophies for endurance performance.	Runners, cyclists, triathletes, and cross-country skiers (N=48)	POL resulted in the greatest improvements in most key variables of endurance performance in well-trained endurance athletes. THR or HVT did not lead to further improvements in performance-related variables.
(Stöggl & Sperlich, 2014)	Comparison of the results of three different training intensities for quantitative methods in adolescent ski athletes.	11 male athletes	The training intensity distribution of high-level athletes shows a significant "polarization" rather than the traditional "pyramid."

Factor Analysis in the Polarized Training Model

The Impact of Polarized Training on Aerobic Capacity (VO_2max)

Research on (VO_2max)

VO_2 max, or maximal oxygen uptake, is a key indicator of aerobic capacity and a vital measure of cardiovascular endurance. In the sports industry, maximum oxygen uptake (VO_2 max) is a critical indicator of the body's demand for oxygen during exercise. Its physiological basis lies in improving the tolerance of the cardiovascular system during physical activity through sustained oxygen intake. Numerous studies have shown that the body's response to oxygen intake and the subsequent expected outcomes differ significantly under varying intensity training models (Nøst et al., 2024) . As a result, oxygen intake has become a key indicator in various training monitoring systems. A large number of studies have studied the relationship between exercise mode and maximum oxygen uptake. The effect of mid-term polarization on maximum oxygen uptake has always been an important research area in this field and has been applied to various types of exercise. Arief et al. (2024) analyzed the effects of two training modes on sports performance (including aerobic endurance and anaerobic capacity) in students aged 19-22 years who were engaged in intermittent sports (including football, futsal, volleyball, basketball, and badminton). The HVIT exercise group showed a significant increase only in the VO_2 Max variable. In addition, the POT exercise group showed a significant increase in the VO_2 Max and anaerobic capacity variables. Therefore, it can be concluded that treatment with the above two methods has a similar impact, namely on the indicators of increasing VO_2 Max, while the advantage of the POT method is that it can increase anaerobic capacity.

Various quantitative studies in this field are also important research projects for researchers. Group experiments are used in the study to explore the changes and effects of maximum oxygen uptake in different types of exercise under planned training modes (Carnes & Mahoney, 2019; Hebisz & Hebisz, 2024) .

In middle- and long-distance running, the application of the polarized training model has led to significant research achievements regarding maximum oxygen uptake under the two training modes. For example, Research indicates that LIT in PT can increase capillary density and enhance fat oxidation, while HIIT effectively maximizes cardiovascular function, thus significantly improving VO_2 max(Bassett & Howley, 2000). In a controlled study involving elite endurance athletes, Stöggl and Sperlich (2015) found that the intensity distribution in PT led to significant improvements in VO_2 max. The combination of low-intensity volume and high-intensity intervals in PT enhances both aerobic base and cardiovascular function, resulting in greater increases in VO_2max compared to traditional endurance training models. This eight-week study revealed that PT participants demonstrated not only shorter recovery times following high-intensity sessions but also marked increases in VO_2 max. Additionally, a six-week experimental study by Treff et al. (2019) on recreational runners showed that VO_2Max in the PT group increased by over 10% compared to the control group. Since recreational athletes typically have lower baseline aerobic adaptation and cardiovascular endurance, PT's dual-stimulation mechanism more effectively boosts their aerobic capacity, suggesting PT's broad applicability across athletic levels.

It can be seen that the use of the polarized training model in middle- and long-distance running has made VO_2 max monitoring an important data monitoring method in current sports research. Oxygen intake data fundamentally reflects the direct impact of training intensity on athletes over the same time.

Theoretical Research on (VO_2 max) Monitoring Experiments

It has been widely established that VO_2 max plays a significant role in predicting performance in endurance sports such as long-distance running, cycling, and rowing. Arief et al. (2024) studied 19-22 year old students who played sports including football, futsal, volleyball, basketball and badminton. They demonstrated that the HVIT training group showed significant increases only in the VO_2 Max variable. The PT training group also showed significant increases in VO_2 Max and anaerobic capacity variables. In studies on ultramarathons, VO_2 max and VO_2 peak are the two primary indicators used. Among these, VO_2peak has proven effective in predicting short-distance performance, while VO_2 max is highly effective in predicting long-distance performance for participants of varying training levels. These studies often utilize both the absolute value and the relative value of VO_2 max to establish relationships. Numerous studies have confirmed the predictive validity of VO_2 max for middle- and long-distance running. This has led to further discussions on which method of calculating VO_2 max offers better predictive accuracy. Specifically, whether it is more effective to use the absolute value of oxygen uptake (L/min), the relative value (ml/min/kg), or other relative value calculation methods (ml/min/kg). In a study by West's team in 1997, it was proposed that energy expenditure has a linear relationship with body weight raised to the power of 0.75 (West et al., 1997) .

In more recent studies, mL/min/kg 0.73 was used as the relative oxygen uptake to better explain the exercise level of high-level athletes, especially in run-based events. To facilitate calculation, recent researchers often approximate mL/min/kg 0.5 for calculation. Some researchers specifically compared the interpretation degree of performance with mL/min/kg 0.73 and mL/min/kg 0.5, and the results showed that mL/min/kg 0.5 had A better interpretation effect (Prapavessis & Grove, 1991) .

From the above studies, it can be seen that the data of VO_2 max are influenced by many factors of control variables, such as the objective situation of athletes' weight, physiological state, and venue, etc. Although mL/min/kg 0.5 may have a better prediction effect on performance, the indicators used in most studies show that most of the studies still adopted relative value (mL/min/kg) or relative value (L/min) indicators. In order to be compared with other studies, the above two indicators were also used as experimental indicators in this study.

TABLE 3 Research on VO_2max literature review results

Researcher	Research purpose	Participants	Research results
(Stöggl & Sperlich, 2015)	Comparison of the differences and adv antages of pyramid training and planne d training	Retrospective study	Polarized training is better than pyramidal training in improving athletes' VO_2 max and endurance
(Carnes & Mahoney, 2019)	To compare running performance and changes in VO_2max and BC between PT and CFE in recreational	Recreational runners (N=21)	Recreational runners achieved similar improvements in 5 km performance and BC with PT or CFE, but POL resulted in greater improvements in

	runners.		VO_2max

TABLE 3 (Continue)

Researcher	Research purpose	Participants	Research results
(Nøst et al., 2024)	Systematically search the literature to identify the effects of polarized training intensity distribution on VO_2max. VO_2peak and economy	Meta-analysis	Polarized training is a beneficial approach for enhancing VO_2max, VO_2peak, and work economy in endurance athletes.
(Arief et al., 2025)	Analyzed the impact of both training models on sports performance, including aerobic endurance and anaerobic capacity	Students who have intermittent sports (19-22 years)	The HVIT exercise group showed significant increases only in the (VO_2 Max) variable. The PT exercise group also showed significant increases in the VO_2 Max and Anaerobic Capacity variables.

(Hebisz & Hebisz, 2024)	Incremental and verification tests were performed to assess VO_2max, peak aerobic power (Ppeak), and power at the second ventilatory threshold (PVT2).	Cyclists (N=7)	The cyclists' VO_2max, Ppeak, and PVT2 all improved through the PT program, and they also performed better in cycling competitions.

Mood and training outcomes in runners

Running is a typical "open skill" sport, and its training process involves continuous physiological stress and psychological investment. In recent years, sports psychology research has found that the emotional state of runners is not only an "outcome variable" of training results (such as the pleasure after performance improvement), but also an "antecedent variable" - positive emotions may enhance training compliance, while negative emotions may induce overtraining or decreased sports performance (Lane et al., 2016b).POMS was developed by Albrecht and Ewing (1989) and assesses the individual's immediate mood state through a 65-adjective scale. It was later modified by sports psychology to form a "simplified POMS" (40-question version). Because of its high reliability and validity (Cronbach's α is usually >0.80), it is widely used for emotional monitoring in endurance events such as running and swimming (Grove & Prapavessis, 1992). The relationship between middle- and long-distance running performance and emotions has been verified by many studies. For example, the average pace of high-energy athletes in a 5-kilometer run was significantly faster than that of the low-energy group (β= -0.42, $p<0.01$)(Martin & Gill, 1995) .

The simplified POMS scale is a commonly used scale model in sports disciplines. Different researchers have different classification methods for the scale. For example, in one study, it was believed that Short-forms of the POMS Meta-analysis five of six POMS subscales (Tension, Depression, Anger, Vigor, Fatigue, but not Confusion).

Confirmatory factor analysis of the POMS did not result in confirmation of the theoretical six-factor model. Principal components factor analyses, as well as confirmatory factor analyses of the six-factor model, provide strong support for the factorial integrity of the EPOMS (Bourgeois et al., 2010) . Lochbaum et al. (2021) , through a meta-analysis of the literature, proposed that the POMS scale and TMD are reliable predictors of athletic performance and athletic performance outcomes in competitive athletes in various sports. Morgan's model, without the anger factor, is still a viable method for understanding and improving athletic performance. This shows that there are many models of the POMS scale in research, and it is necessary to find a suitable model and scoring method for this study.

The application of the POMS scale and sports science experimental monitoring has become relatively mature, and scholars have established a research foundation on the performance and application of the scale in sports discipline monitoring. In 2023, Chinese scholars Pang Liang, Xie Xinyi, and Lin Yigang studied whether mood or emotional state affects track and field performance. Through the collection and analysis of mood state scale data, the impact of emotions on track and field sports was studied, which shows that the POMS scale can obtain statistical data and analytical significance in running (Pang et al., 2023).

TABLE 4 Research on Sports Psychology Literature Review Results

Researcher	Research purpose	Participants	Research results
(Lane et al., 2016a)	I(Albrecht & Ewing, 1989)nvestigated the effects of online self-help interventions	Runners (N = 147)	Post-intervention emotions were significantly more pleasant and less unpleasant. Emotion-performance satisfaction relationships strengthened post-intervention.

(Albrecht & Ewing, 1989)	To describe the POMS protocol, and provide a standardized list to increase uniformity of management procedures	Psychological Experiments	Confirm the availability of the scale

TABLE 4 (continue)

Researcher	Research purpose	Participants	Research results
(Grove & Prapavessis, 1992)	Tested the utility of Mhgan's (1980) Mlotdhel and Hanin's (1980) Zone of Optimal Function Model in an ecologically valid environment.	12 high-performance shooters	Results revealed partial Support for Hanin's model but no support for Morgan's model.
(Lochbaum et al., 2021)	To explore the application and feasibility of the POMS scale in kinematics	Meta-analysis	Most of the POMS scales and TMD are reliable predictors of sport performance in competitive athletes across a wide variety of sports and athletic performance outcomes.

(Bourgeois et al., 2010)	Provide indicators of the reliability and validity of the POMS, and compare the reliability characteristics of the POMS and the POMS-Short Form	Meta-analysis	Principal component factor analysis and confirmatory factor analysis of the six-factor model provided strong support for the factorial integrity of the EPOMS.

TABLE 4 (continue)

Researcher	Research purpose	Participants	Research results
(Pang et al., 2023)	Explore whether mood or emotional state influences performance in athletics.	Athletics (Track N=57, Field N=45)	Decreased vitality and increased fatigue during training were associated with decreased depression and fatigue before competition, while increased vitality; and NEP were associated with observation time. High performance in field events was associated with decreased anger, increased viewing of positive PEPs, and decreased counts of NEPs.

It can be seen from the literature research that most of the experiments related to endurance events are designed according to the ratio of (80:20) using the polarized training method. The results were obtained by monitoring VO_2max, running economy, and fatigue index. In terms of results, professional athletes can improve their endurance and performance by improving VO_2max and running economy through polarization training. On the other hand, psychological scales also play a monitoring role in sports evaluation. Most studies use the POMS scale. The research results show that the simplified POMS scale is useful for monitoring the fatigue level of trainees and the relationship between psychology and training patterns.

This chapter reviews the basic concepts and framework methods of polarized training through a literature study. Numerous previous studies have demonstrated that the polarized training model significantly improves endurance sports performance. By monitoring three key aspects—aerobic capacity, middle- and long-distance running results, and perceived fatigue—scientific conclusions can be drawn. These research data have been positively validated in the past, establishing a theoretical foundation for using polarized training monitoring methods and factor monitoring in cyclical middle- and long-distance running. This foundation will also provide a solid basis for the research conducted in Chapter 3.

CHAPTER 3

METHODOLOGY

Determination of population and sample groups

Population

The study population consists of male university middle-distance runners aged 18 to 25, who actively participate in university-level competitions and have at least one year of systematic training experience in 800 to 1500-meter events.

Participants

In previous experiments (González-Mohíno et al., 2016), which is calculated from an effect size of 0.67 and a test power of .80. The sample size of 24 participants was determined based on previous literature. A total of 24 middle-distance runners from Guangxi Vocational and Technical College of Mechanics and Electricity were selected using purposive sampling. The participants were then randomly assigned into two groups: an experimental group and a control group, each consisting of 12 runners based on VO_2max for separate groups. The experimental group underwent a polarized training intervention, while the control group continued with their regular training regimen. The subjects were stratified using VO_2max values, with the PT group consisting of participants with VO_2max values in the order of 1, 4, 5, 8, 9, 12, 13, 16, 17, 20, 21, and 24, and the other orders as the control group. This stratification represents a measure of the differences in athletes' performance.

Inclusion Criteria

1.Athletes with At least 1 year of competitive middle-distance running experience (800m-1500m)

2. Athletes who were injury-free for the past 6 months.

3. Athletes with a VO_2max greater than 50 ml/kg/min.

4.Athletes must sign a consent form to voluntarily participate in the training program, acknowledging responsibility and understanding of the study requirements.

Exclusion Criteria

1. Athletes with any form of injury during the experiment.

2. Athletes experiencing any discomfort or health issues during the training period have the option to withdraw from the study.

Tools used in research

Measuring tools

Yo-Yo IR1

Yo-Yo IR1 is a standardized physical fitness assessment tool developed by the team of Danish exercise physiologist Jens Bangsbo. focusing on assessing the intermittent endurance level of athletes(Bangsbo et al., 2008). The formula for calculating the maximum oxygen uptake proposed in this study Yo-Yo IR1 test: VO_2max (mL/min/kg) = YO-YO IR1 distance (m) × 0.0084 + 36.4, Reliability and validity (r =0.77), studied by (Krustrup et al., 2003). Conducted a YO-YO test on 17 male athletes and concluded that this test method has high repeatability and sensitivity and can be used to analyze the physical fitness of athletes in intermittent exercise in detail.(Krustrup et al., 2003). Similarly, Krustrup et al. (2003) found an ICC range of 0.85-0.95 in Danish adolescent athletes, confirming its stability.

Heart Rate Monitor

Xiaomi wristbands have a certain foundation and experimental experience in the field of sports monitoring. Shi (2023). Using Xiaomi Mi Band 7 to monitor and record the heart rate and blood oxygen saturation of basketball players, a positive experimental result was obtained. Training Protocol.

Development of Training Protocols

The polarized training programs were developed and validated through consultations with five experts, 5 people in sports science and exercise physiology. Content validity was established using expert evaluations, where each component of the program demonstrated an Index of Item-Objective Congruence (IOC) value greater than 0.80, indicating high consistency in terms of the relevance and clarity of the training content. Adjustments to the training protocols were made to ensure that they met both the competitive needs of the athletes and adhered to rigorous scientific standards. This iterative process, involving expert reviews and modifications, ensured that the training protocols were both practically applicable and scientifically robust.

Methodological Strategies in Special Circumstances

Special Populations and Special Timing: Due to the use of wearable data sampling tools, there are certain issues with special populations and special periods, requiring methodological setup before data collection. First, for individuals prone to sweating, it is necessary to prepare towels or tissues in advance to wipe off sweat during testing. Second, during summer, excessive sweating can occur during exercise. Ensure that medical alcohol wipes are used to clean devices after each training session, and appropriately increase the cleaning frequency of instruments.

Emergency or Unexpected Situations: If an athlete fails to wear the device or if data collection anomalies result in partial data loss under special circumstances, the coach's training log can be used as a reference sample to compile training data.

Variable Control Measures

Limit non-experimental activities. During the experiment, participants are prohibited from participating in high-intensity exercise. The Xiaomi sports bracelet is used to monitor and record daily activity to ensure that the additional consumption is $\leqslant$ 10% of the experimental training volume.

The experimenters were forced to rest from 22:30 to 6:30 every day, and use smart bracelets to monitor the duration of deep sleep. During the experiment, the experimenters could not drink alcohol or eat a lot of high-calorie foods, but could eat according to the recommended diet. After training, they took alternating hot and cold showers and had sports massage once a week (focusing on the lower limb muscles).

Before the experiment, immune screening was performed to avoid colds and other conditions that affect the state, the real-time temperature. Record the temperature on the day of training and compare it with historical data for the same period (the average temperature in Nanning in April is 25 degrees Celsius)

Pilot Study

A pilot study was conducted before the start of the formal research, involving three athletes to assess the feasibility of the training program and measurement procedures. This preliminary study helped refine the data collection methods and ensured that all equipment functioned correctly under research conditions. Based on the feedback from the pilot study, adjustments were made to the research design to optimize the study process. Conducting the pilot study before the proposal exam allowed for any necessary modifications to be implemented, ensuring that the protocols and equipment used in the main study were accurate and feasible.

IOC and Ethics

To ensure the scientific nature of the experimental design, five experts in sports research were invited to evaluate the experimental plan before the experiment began. The IOC score (Appendix C) was 0.82, which exceeded the recommended score of 0.8, proving the scientific nature of the experimental design. The research will conduct sports physiological observations on humans, the research was applied for and passed ethical review, and the review number is: GXGS-2025BS-0320 (Appendix E)

Methods of data collection

Overview of the research process

This study investigates the effects of polarized training on middle-distance runners through a six-week intervention. Participants were randomly assigned to two groups: one group followed a polarized training model (alternating low- and high-intensity training), while the control group continued their regular unstructured training routines without intervention. The study employed a pre-test, mid-test, and post-test framework to systematically monitor aerobic and anaerobic adaptations, focusing on changes in VO_2 max, 800-meter and 1,500-meter, and Profile mood stage.

The environmental conditions during the training and testing sessions were carefully controlled to ensure both the safety of the participants and the reliability of the results. The daily average temperature ranged between 22℃ and 34℃, with humidity levels fluctuating between 70% and 90%. To mitigate the risk of heat stress, testing was scheduled at 18:00, avoiding the peak heat period at noon. This timing also ensured that participants had a full 24-hour rest period prior to the test.

For environmental control, testing was conducted on a plastic track, which provides a consistent and reliable surface. The area was selected for its good ventilation, ensuring proper air circulation to help manage heat levels. Additionally, no significant wind direction interference was present during the testing period, further stabilizing environmental conditions.

The "Periodization of Training" is detailed in Part 2 of the 6th edition of "Periodization of Training" (Bompa & Buzzichelli, 2015). Under this theoretical framework, it is proposed that Training Cycles are divided into microcycles of 1 week and 7 days and macrocycles lasting 2 to 7 small cycles. In this study, the period was set at 6 weeks. Prior to the age and physiological state of the experimental subjects, in the low-intensity training, the training time was set to be less than 60 minutes in the Z1 stage and 70 minutes in the Z3 stage

Assessments were conducted at three key time points: baseline (Week 0), mid-test (Week 3), and post-test (Week 6). During each phase, consistent laboratory conditions were maintained to control variables such as temperature, humidity, and testing schedules, ensuring data reliability. By evaluating the distinct physiological responses of the two groups, this study aims to provide evidence-based insights into the effectiveness of polarized training in enhancing performance among middle-distance runners.

General data collection procedures

Participant Orientation and Informed Consent

Before beginning the study, researchers provided each participant with a thorough explanation of the training program, objectives, and study requirements. The athletes were instructed on the specific protocols for polarized and threshold training, detailing the importance of adherence to training intensity and duration. Participants were also informed about the testing procedures and the importance of consistent effort and safety. All participants signed an informed consent form, voluntarily agreeing to participate and acknowledging their understanding of the study's purpose and potential physical demands.

Polarized Training Program

This six-week polarized training program combines low-intensity training (LIT) and high-intensity interval training (HIIT) to optimize both aerobic and anaerobic adaptations for amateur middle-distance runners. Each week includes five training days, structured with two days of low intensity, one day of high intensity, followed by two additional days of low-intensity training, designed to achieve optimal physiological adaptations. HR max from the VO_2max test will be used to determine the HR of training. POMS was measured before every week's training (First training session).

Training control

To ensure that the subjects' heart rates meet the requirements of the experimental design, the subjects need to wear the Xiaomi health bracelet and set the heart rate range through the Xiaomi Sports Health app. During the training process, if the heart rate is higher or lower than the set range, the bracelet will beep and turn on the red or green light. The monitoring data will be shared and displayed through the community function, and researchers can monitor in real time whether the subjects meet the heart rate conditions.

FIGURE 2 Xiaomi smart bracelet heart rate monitoring and blood oxygen monitoring

Control group training (CG)

Typical training is 5 days per week. Most training programs focus on extensive endurance at 60-75% of maximum heart rate, alternating with Intensive Endurance on some training days, under coach supervision. The total duration of the session is approximately 60-90 minutes/time.

Polarized training program (PTG)

Low-Intensity Training (LIT)

Objective: The primary goal of low-intensity training is to enhance aerobic capacity, increase capillary density, and promote fat oxidation, thereby delaying fatigue onset. This type of training builds a robust endurance base crucial for middle-distance performance.

Training Format: LIT consists of steady-state running, maintaining heart rate within 60-65% of maximum heart rate (HRmax).

Duration: Each session lasts 60-90 minutes, adjusted according to each runner's endurance level to ensure adequate aerobic stimulation.

Frequency: LIT is performed four times a week, accounting for 80% of the total weekly training volume.

High-Intensity Interval Training (HIIT)

Objective: The purpose of high-intensity interval training is to enhance maximal oxygen uptake (VO_2 max), anaerobic endurance, high-intensity bursts, effectively stimulating anaerobic metabolism.

Training Format: HIIT sessions include intervals of 4-8 minutes at high intensity, followed by 2-3 minutes of active recovery (low-intensity jogging or walking) to aid in lactate clearance and reduce heart rate. Each HIIT session consists of 4-6 intervals to ensure sufficient anaerobic stimulation.

Intensity: The target heart rate during HIIT intervals is 90-95% of HRmax, providing an effective high-intensity stimulus to improve lactate threshold and running efficiency.

Duration: Each HIIT session has a total duration of 30-45 minutes, including intervals and recovery, and is performed once a week, representing 20% of the total weekly training volume.

Mid-Test Adjustment

At the end of Week 3, a mid-test was conducted to evaluate each participant's progress. Participants were required to rest for 48 hours to ensure the accuracy of the test data. Based on the results, the target intensity for HIIT sessions was adjusted from 90% to 95% of maximum heart rate to reflect the athletes' improved fitness levels. This adjustment ensured that the training stimulus continued to be challenging and effective as athletes progressed.

First phase (Weeks 1-3): During the initial three weeks, participants in the polarized training group primarily engaged in low-intensity aerobic training, accounting for approximately 80% of the total training volume, complemented by high-intensity interval training making up the remaining 20%. The low-intensity sessions lasted 60-90 minutes each, focusing on building an aerobic base with a steady-state heart rate of 60-65% of HRmax. High-intensity intervals were scheduled once a week, targeting 90-95% HRmax in 4-8 minutes intervals with active recovery in between. In contrast, the control group continued their regular unstructured training routines, allowing for a baseline comparison without specific intervention. This weekly data allowed the researchers to assess each group's adaptation to the training protocol and ensure safety and adherence.

Second phase (Weeks 4-6): For the second half of the study, both groups continued with their respective training protocols, with progressive adjustments to training duration rather than intensity. Low-intensity session lengths for the polarized group were gradually extended by 5-10 minutes each week to increase endurance demands while keeping intensity within the 60-65% HRmax range. High-intensity intervals maintained the same intensity but could include additional intervals based on weekly adaptation metrics, as heart rate and perceived exertion data. In contrast, the control group continued their regular unstructured training routines, allowing for a baseline comparison without specific intervention.

At the end of Week 6, comprehensive performance evaluations were conducted, including VO_2 max testing, 800 meter and 1,500 meter, and Profile mood stage test. The final performance test results were compared to the baseline and mid-study data to evaluate each group’s progress and assess the impact of polarized training on key performance metrics.

To adapt the training load to each athlete's conditioning, preventing plateau effects, and optimizing training benefits in the latter half of the program.

TABLE 5 Polarized Training Group Schedule

<table>
<tr><th>Phase</th><th colspan="3">Program detail</th></tr>
<tr><td>Pre test</td><td colspan="3">800-meter, 1,500 meter, and Yo-Yo IR1</td></tr>
<tr><td rowspan="2">First Phase
(Weeks 1-3)</td><td colspan="2">PT Group</td><td>Control Group</td></tr>
<tr><td>High Intensity
15 minutes
(90-95% HRmax)</td><td>Low Intensity
60 minutes
(60-65% HRmax)</td><td>Individual
regular
Training Mode</td></tr>
<tr><td>Mid test</td><td colspan="3">800-meter, 1,500 meter, and Yo-Yo IR1</td></tr>
<tr><td rowspan="2">Second Phase
(Weeks 4-6)</td><td colspan="2">PT Group</td><td>Control Group</td></tr>
<tr><td>High Intensity
25 minutes
(90-95% HRmax)</td><td>Low Intensity
70 minutes
(60-65% HRmax)</td><td>Individual
regular
Training Mode</td></tr>
<tr><td>Post test</td><td colspan="3">800-meter, 1,500 meter, and Yo-Yo IR1</td></tr>
<tr><td colspan="4">*POMS measured before every week’s training (First training session)</td></tr>
</table>

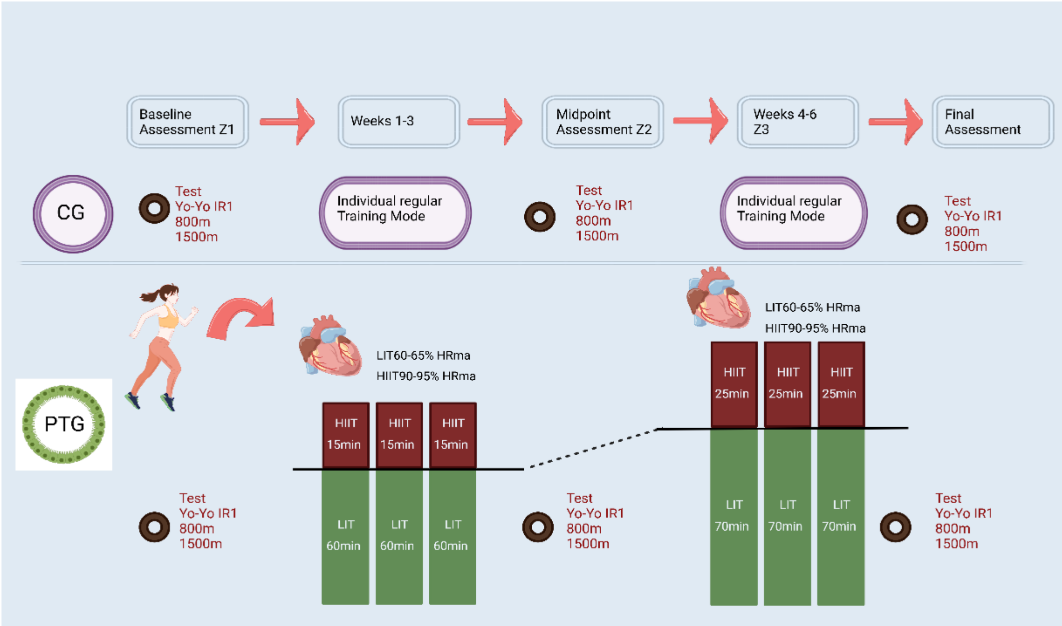

FIGURE 3 Enhanced Weekly Distribution and Intensity Adjustment in Polarized Training Program

Description: This figure illustrates the weekly distribution of Low-Intensity Training (LIT) and High-Intensity Interval Training (HIIT) over a six-week training program, as well as the intensity adjustment made after the mid-test at Week 3.

(a) Weekly Training Volume Distribution (LIT vs. HIIT): Shows the proportion of weekly training time dedicated to LIT (80%) and HIIT (20%). LIT heart rate is maintained at 60% - 65%. The mid-test adjustment point is marked at Week 3, indicating the evaluation point for potential adjustments based on participant progress.

(b) HIIT Intensity Progression Over Time: Displays the targeted intensity for HIIT sessions, expressed as a percentage of maximum heart rate (% Max HR). HIIT maximum heart rate is maintained at 90%-95%, and the intensity is increased after the mid-term to obtain the difference value by increasing the training time.

The whole training is divided into several stages, and the original data is collected before the start. The first period is from the first week to the third week. After the third week of training, it is necessary to rest for 48 hours before interim data collection. From the fourth week to the sixth week, according to the plan, the training time was extended under the condition of constant heart rate to stimulate the sample to get a change in data value. Data values were obtained from the recent final test after the end of the sixth week.

Measurement of variables

Yo-Yo IR1 Test

VO_2max was tested using the Yo-Yo Interval Recovery Test Level 1 (Yo-Yo IR 1) on an outdoor football field 100 m long and 64 m wide. The test consisted of running 20 m (180-degree turn) with an audio prompt to determine the desired running speed, using a 20 m running track with a 5 m rest period. After each 40 m run, the participant had a 10 s active rest period before running another 40 m. The test consisted of running 4 laps at a speed of 10-13 km/h (distance 0-160 m), followed by 7 laps at a speed of 13.5-14 km/h (distance 160-440 m). The test then continued every 8 laps at an additional 0.5 km/h speed. The maximum test speed was 19 km/h. The total test distance was 3,640 m. If an athlete fails to reach the finish line before the “beep” sound for two consecutive times, the race ends, and the final finish level is recorded.

800-meter and 1,500-meter test

The 800m and 1500m tests were conducted on a standard 400m track. Stopwatches, whistles, record boards and supervisors were prepared in advance to ensure that the track was clear and to record any violations, such as false starts and shortcuts. The test was conducted in two groups: the control group and the PT group. A standing start was used. Athletes remained silent when they heard "on your marks" and started when they heard the whistle. If there was a false start, they would be called back and restarted. The standard for crossing the finish line was the torso, not the head or limbs. The results were recorded to the nearest 0.01 second.

Profile of Mood States (POMS)

The Assessment of Fatigue and Recovery used the Mood State Scale to assess athletes' subjective fatigue levels and monitor perceived fatigue fluctuations throughout the training period, helping to identify signs of overtraining and recovery needs.

Measurement method

The Profile of Mood States was recorded before intervention evaluation every day. This frequency enables tracking of cumulative fatigue and recovery over time. To avoid the influence of non-experimental interference factors on the experimental results as much as possible, the mood state scale (short form POMS scale) was given to the subjects to fill in before each experiment.

Profile of Mood States (POMS)

Please use the following words to express how you felt during the previous week (including today). For each adjective, choose only one of the five options that best matches your feelings and put a "0", "1", "2", "3", or "4" in the corresponding small square (Prapavessis & Grove, 1991)

Measurement Procedure

Participants completed the AFQ at the end of each training week and during scheduled performance evaluations. The questionnaire assessed cumulative fatigue and recovery status, providing insights into how training load affects overall well-being and performance readiness.

The scoring method for this scale is as follows: "almost none" is 0 points, "a little" is 1 point, "moderate" is 2 points, "quite a lot" is 3 points, and "very" is 4 points. It should be noted that two of the indicators are scored in the opposite way to the others (Appendix E). The items for the seven components are Abbreviated POMS Questionnaire (Grove & Prapavessis, 1992) (items and scoring key):

TEN = Tension	Note that 2 of the items on the Esteem-related Affect (ERA) subscale are reverse-scored prior to being combined with the other items.
ANG = Anger	**Total Mood Disturbance (TMD)** is calculated by summing the totals for the negative subscales and then subtracting the totals for the positive subscales:
FAT = Fatigue	TMD = [TEN+DEP+ANG+FAT+CON] – [VIG+ERA].
DEP = Depression	A constant (e.g., 100) can be added to the TMD formula in order to eliminate negative scores.
ERA = Esteem-related Affect	
VIG = Vigour	
CON = Confusion	

FIGURE 4 Brief definitions of mood state indicators and calculation instructions for total mood disorder (TMD)

Source: Grove and Prapavessis (2016)

Statistical Analysis.

Data processing and analysis

SPSS (version 24) was used to analyze the collected data. Statistical analyses included

Descriptive Statistics

Mean and standard deviation of variables such as VO_2 max, 800-meter and 1,500-meter tests, and POMS were calculated.

Shapiro-Wilk Test

Used to check the normality of data distribution to ensure it met the assumptions for parametric tests. A significance level of $p < 0.05$ was used.

Repeated Measures ANOVA

The Two-way Repeated measures ANOVA (Two-way ANOVA with repeated measures) was used to evaluate the differences in performance between groups (PT and CG) x time (pre-test, mid-test, and post-test), analyzing the interaction effects of the training program and time on fitness indicators. The specific variables measured and analyzed included: 800-meter, 1,500-meter, Maximal Oxygen Uptake (VO_2max), and an independent sample T-Test was analyzed between groups for Profile of Mood States (POMS), each profile.

CHAPTER 4
RESULTS

Data analysis results presentation

The present fashion of results is divided into two main parfs:1. basic characteristics of the sample group and 2. sports performance outcomes.

Sample data

The sample group of this study has general physical characteristics

TABLE 6 General physical characteristics information

Physical Characteristics	Mean ± SD (CG)	Mean ± SD (PTG)
Age (years)	19.33±0.65	19.00±0.60
Height (cm)	174.25±3.47	176.00±3.41
Weight (kg)	62.92±7.62	61.83±5.54
800M(min:sec)	02:44.81±0:14.44	02:42.42±0:16.10
1500M(min:sec)	05:44.87±0:28.47	05:40.96±0:50.92
VO_2max (ml/kg/min)	50.42±1.19	50.21±1.19

Compare the results of the 800-meter test between CG and PTG.

The results of the study found that there was an interaction of time slot x training program of the mean 800-m running time p = 0.048 at each CG and PTG time point, with PTG having a statistically significant decreasing trend of time $p < 0.05$ (Table 5), but the decreasing trend of PTG (02:28.40±0:9.28min: sec) was higher than that of CG, especially the pots-test (0:36.51±0:12.79 min: sec).

The results of the comparison of the influence within the groups found that the training program had a statistically significant decrease in time in both groups at the p = 0.01 level. It was found that in the CG group, the mean in the post-test period,02:36.51±0:12.79 min: sec, was lower than the pre-test period, 02:44.81±0:14.44 min: sec, p =0.001, and the mid-test period, 160.45±13.06 seconds, p = 0.002. In the

PTG group, the mean in the post-test period, 02:28.40±0:9.28min: sec, was lower than the pre-test period,2:42.42±0:16.10 min: sec, and the mid-test period,02:35.20±0:12.17 min: sec, was statistically significant at the p = 0.001 level.

The results of the comparison of influences between groups at each period found that the mean of both groups was not significantly different at the p = 0.0394 level. All data showed in table 7 to table 9.

TABLE 7 The two-way ANOVA with repeated measures in the 800-meter test

Test	Mean Square	Partial Eta Squared	F	Sig
Within group	747.944	0.80	84.864	0.001*
Between group	378.583	.033	0.756	0.394
Interaction (Group x time)	51.140	0.251	3.528	0.048*

Note: *p < 0.05 indicates statistically significant difference.

TABLE 8 The result of the test within groups in the 800-meter test

Group	Pre-test	Mid-test	Post-test	P
CG (min: sec)	02:44.81±0:14.44	02:40.45±0:13.06	02:36.51±0:12.79	0.001*
PTG (min: sec)	02:42.42±0:16.10	02:25.20±0:12.17	02:28.40±0:9.28	0.001*

Note: CG: Control group, PTG: Polarized training group

*p < 0.05 indicates statistically significant difference.

TABLE 9 Analysis of within-group comparison of 800-meter running performance.

Group	Pre-test	Mid-test	Post-test
CG (min: sec)	02:44.81±0:14.44	02:40.45±0:13.06	02:36.51±0:12.79
PTG (min: sec)	02:42.42±0:16.10	02:35.20±0:12.17	02:28.40±0:9.28
P value	0.826	0.319	0.013*

Note: CG: Control group, PTG: Polarized training group

*p < 0.05 indicates statistically significant difference.

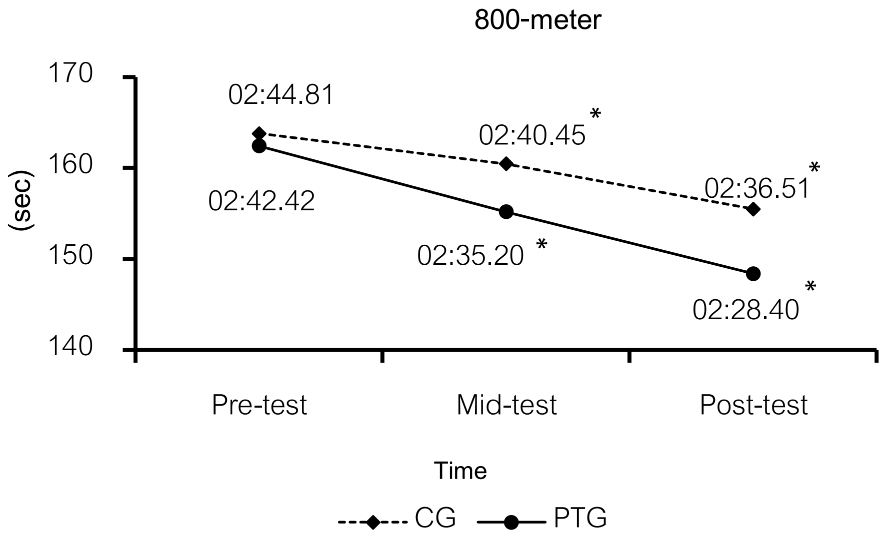

FIGURE 5 Differences in 800 m mid-test and post-test within training

Note: CG: Control group, PTG: Polarized training group

*p < 0.05 indicates statistically significant difference.

Compare the results of the 1500-meter test between CG and PTG.

The results of the study found no interaction of time slot x training program on the mean 1500-meter running time, p = 0.064.

The results of the comparison of the influence within the groups found that the training program had a statistically significant decrease in time in both groups at the p = 0.01 level. It was found that in the CG group, the mean in the post-test period,5:25.48±0:21.81 min: sec, was lower than the pre-test period, 05:44.87±0:28.47 min: sec, p =0.001 and the mid-test period, 05:37.81±0:24.38 min: sec, p = 0.012. In the PTG group, the mean in the post-test period, 05:18.21±0:22.08 min: sec, was lower than the pre-test period, 05:40.96±0:50.92 min: sec, and the mid-test period, 05:34.41±0:25.85 min: sec, was statistically significant at the p = 0.001 level.

The results of the comparison of influences between groups at each period found that the mean of both groups was not significantly different at the p = 0.719 level. All data showed in table 10 to table 12.

TABLE 10 The two-way ANOVA with repeated measures in 1,500-meter test

Test	Mean Square	Partial Eta Squared	F	Sig
Within group	2784.623	0.867	142.800	0.001*
Between group	253.200	.006	0.133	0.719
Interaction (Group x time)	56.967	0.117	2.921	0.064

Note: *p < 0.05 indicates statistically significant difference.

TABLE 11 The result of test within group in 1,500meter test

Group	Pre-test	Mid-test	Post-test	*P*
CG (min: sec)	05:44.87±0:28.47	05:37.81±0:24.38	05:25.48±0:21.81	0.001*
PTG (min: sec)	05:40.96±0:50.92	05:34.41±0:25.85	05:18.21±0:22.08	0.001*

Note: CG: Control group, PTG: Polarized training group

*p < 0.05 indicates statistically significant difference.

TABLE 12 The result of test between group in 1,500-meter test

Group	Pre-test	Mid-test	Post-test	Sig
CG (min: sec)	05:44.87±0:28.47	05:37.81±0:24.38	05:25.48±0:21.81	0.698
PTG (min: sec)	05:40.96±0:50.92	05:34.41±0:25.85	05:18.21±0:22.08	
P value	0.895	0.817	0.425	

Note: CG: Control group, PTG: Polarized training group

*p < 0.05 indicates statistically significant difference.

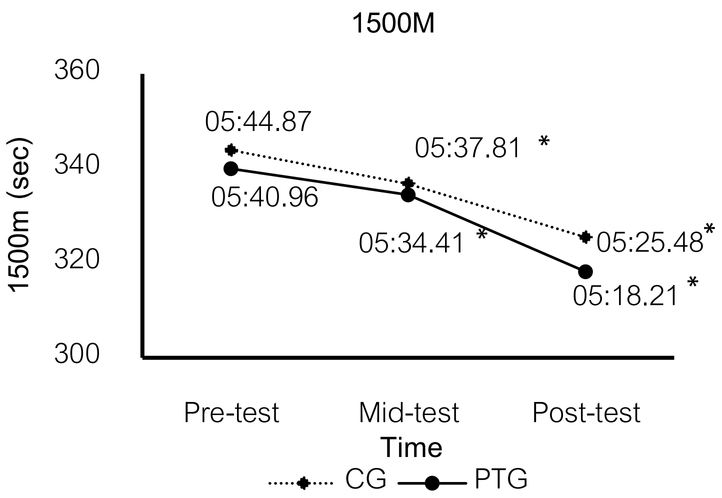

FIGURE 6 Differences in 1500 m mid-test and post-test within training

Note: CG: Control group, PTG: Polarized training group

*p < 0.05 indicates statistically significant difference.

Compare the results of VO_2max test between CG and PTG.

The results of the study found that there was an interaction of time slot x training program on VO_2max values from Yo-Yo IR1 test at each time point that was different between CG and PTG, where PTG had a tendency of increasing score at a higher rate than CG and CG had a period of decreasing mean value in mid-test and had a statistically significant difference in post-test at $p < 0.05$.

The results of the comparison of the influence within the groups showed that the training program increased in both groups with statistical significance at the p <0 .01 level. It was found that in the CG group, the mean score in the pre-test period; 50.42±1.19 ml/min/kg was higher than the post-test period; 50.63±1.02 ml/min/kg p <0 .010 and the post-test period 50.63±1.02 ml/min/kg was higher than the mid-test period; 50.28±1.05 ml/min/kg with statistical significance at the p <0 .001 level. However, no differences were found between the pre-test and the mid-test. In the PTG group, the mean score in the mid-test period; 50.71±1.60 seconds was higher than the pre-test period; 50.71±1.60 ml/min/kg, p < 0.001 and the post-test period 51.36±1.45 ml/min/kg was higher than the mid-test period; 50.28±1.05 ml/min/kg and the pre-test period; 50.71±1.60 ml/min/kg with statistical significance at the p < 0.001 level.

The results of the comparison of influence between the groups at each time point showed that the two groups were significantly different at the p = 0.016 level in the post-test period, with the PTG (51.36±1.45 ml/min/kg) having a higher mean than the CG (50.63±1.02 ml/min/kg). All data showed in table 13 to table 15.

TABLE 13 The two-way ANOVA with repeated measure in VO_2max from Yo-Yo IR1 test

Test	Mean Square	Partial Eta Squared	F	Sig
Within group	4.751	0.810	93.677	0.001*
Between group	3.781	.030	0.676	0.420
Interaction (Group x time)	0.416	0.272	8.207	0.006*

Note: *p < 0.05 indicates statistically significant difference.

TABLE 14 The result of test within group in VO_2max from Yo-Yo IR1 test

Group	Pre-test	Mid-test	Post-test	*P*
CG (ml/min/kg)	50.42±1.19	50.28±1.05	50.63±1.02	0.001*
PTG (ml/min/kg)	50.21±1.19	50.71±1.60	51.36±1.45	0.001*

Note: CG: Control group, PTG: Polarized training group

*p < 0.05 indicates statistically significant difference.

TABLE 15 The result of test between group in VO_2max from Yo-Yo IR1 test

Group	Pre-test	Mid-test	Post-test
CG (ml/min/kg)	50.42±1.19	50.28±1.05	50.63±1.02
PTG (ml/min/kg)	50.21±1.19	50.71±1.60	51.36±1.45
P value	0.738	0.442	0.016*

Note: CG: Control group, PTG: Polarized training group

*p <0 .05 indicates statistically significant difference.

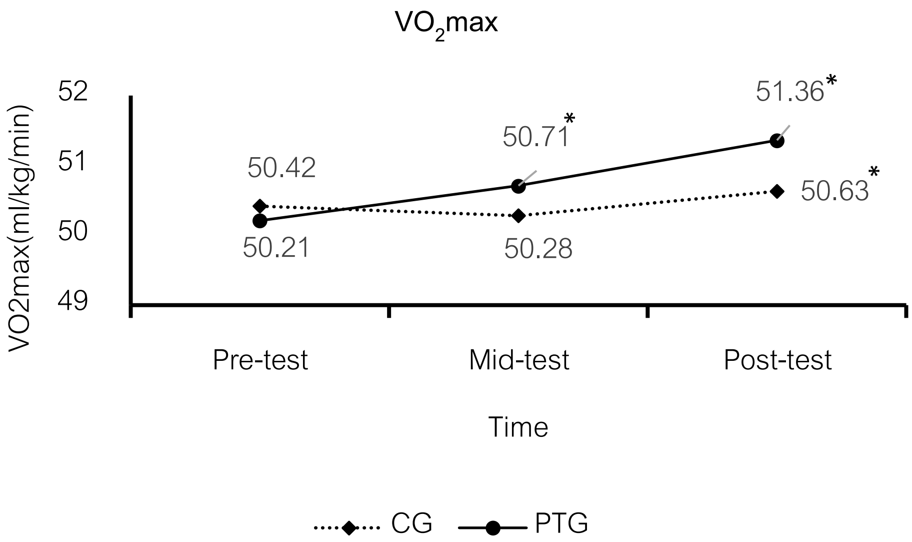

FIGURE 7 Differences in VO2max revise this caption

Note: CG: Control group, PTG: Polarized training group

*p < 0.05 indicates statistically significant difference.

Compare the results of the POMS test between CG and PTG.

The independent sample T-Test statistical analysis of Profile of Mood States (POMS) found that Tension in CG (13.16±0.40) had a significantly higher mean than PTG (10.39±0.27) at p = 0.001. Depress in CG (18.64±0.66) had a significantly higher mean than PTG (15.02±0.36) at p = 0.001. Anger in CG (14.33±0.44) had a significantly higher mean than PTG (11.00±0.46) at p = 0.020. Vigor in CG (13.54±0.20) had a significantly higher mean than PTG (11.23±0.38) at p = 0.008. Self-esteem in PTG (19.86±0.32) had a significantly higher mean than CG (15.41±0.31) at p = 0.001. Confusion in CG (14.60±0.46) had a significantly higher mean than PTG (12.80±0.36) at statistical significance at p = 0.042, and Total Mood Disturbance (TMD) in CG (48.62±1.49) was significantly higher than PTG (34.99±0.76) at statistical significance at p = 0.001. Finally, no difference in Fatigue. All data showed in table 16.

TABLE 16 Average Profile of Mood States (POMS) of CG and PTG

Profile	Group	Mean ± SD	*P*
Tension	CG	13.16±0.40	0.001*
	PTG	10.39±0.27	
Depression	CG	18.64±0.66	0.001*
	PTG	15.02±0.36	
Anger	CG	14.33±0.44	0.020*
	PTG	11.00±0.46	
Vigor	CG	13.54±0.20	0.008*
	PTG	11.23±0.38	
Self Esteem	CG	15.41±0.31	0.001*
	PTG	19.86±0.32	
Fatigue	CG	13.30±0.38	0.379
	PTG	13.41±0.23	
Confusion	CG	14.60±0.46	0.042*
	PTG	12.80±0.36	
TMD	CG	48.62±1.49	0.001*

Note: CG: Control group, PTG: Polarized training group

*$p < 0.05$ indicates statistically significant difference

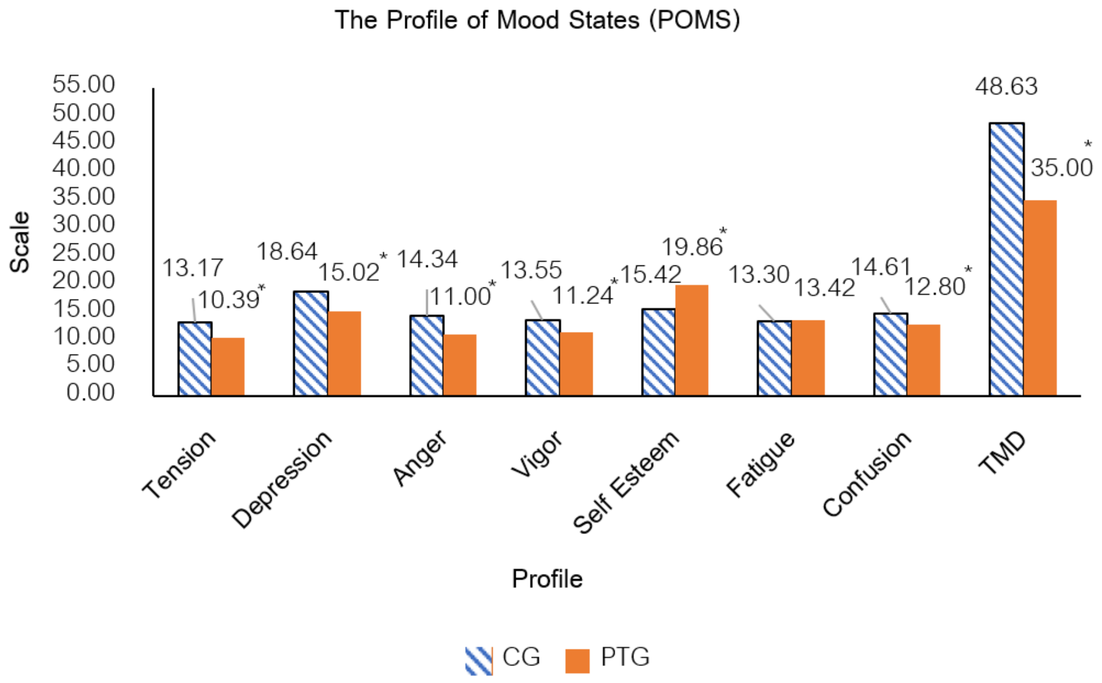

FIGURE 8 Differences in POMS post-test training

Note: CG: Control group, PTG: Polarized training group

*$p < 0.05$ indicates statistically significant difference

CHAPTER 5
DISCUSSION AND CONCLUSION

Polarized Training (PT) has become a widely used training method in endurance sports, particularly in middle-distance running and other endurance events. This PT intensity distribution significantly reduces the occurrence of “training plateaus” (i.e., physiological adaptation stagnation), thereby maximizing the benefits of both low-intensity and high-intensity training. As a result, Polarized Training (PT) can maximize training effectiveness while minimizing the risk of overtraining. This method is particularly beneficial for middle-distance running (800–1,500 meters), as it requires a combination of aerobic and anaerobic systems, demanding athletes to balance endurance and speed. In practice, the implementation of polarized training relies on two additional key parameters: training zones and training cycles. According to Tudor O.'s theory, any training involves stages such as physiological adaptation, maximum strength, and power conversion, which collectively form a training cycle. Only through the combined effects of the cycle and training zones can training achieve the desired results. In the polarized training model, the influence of the training cycle and training zones on training outcomes is particularly significant. The findings suggest that a polarized training approach appears to be effective in enhancing VO_2max, VO_2peak, and work economy over a short-term period for endurance athletes. Specifically, a training intensity distribution involving a moderate to high volume of HIIT (15–20%) combined with a substantial volume of LIT (75–80%) appears to be the most beneficial for these improvements. It was concluded that polarized training is a beneficial approach for enhancing VO_2max, VO_2peak, and work economy in endurance athletes (Hebisz & Hebisz, 2024). LIT is training below the lactate threshold, during LIT training, lactate begins to accumulate in the blood faster than it can be cleared. LIT training can improve mitochondrial capacity and capillary density, thereby achieving better oxygen uptake capacity. While the effectiveness of PT has been widely validated among elite athletes, research on its impact among amateur middle-distance runners remains insufficient. This study aims to determine whether a six-week polarized training intervention can significantly improve the maximum oxygen uptake of amateur middle- and long-distance runners, thereby providing quantitative evidence to enhance endurance performance. This study will outline the conclusions and discussions in the following order: Discussion of results, findings, suggestions for further research, and practical application of research results.

Discussion of Research Results

VO_2max

Volume uptake changed significantly in the CG and PTG. Significant changes in VO_2max values were observed in both the Control Group and the polarized training group. This is consistent with the results of the study by Stöggl & Sperlich (2015), who observed significant improvements in VO_2max in the PL Group. Although the maximum oxygen uptake in the Control Group also changed, this is a normal physiological performance after exercise. In the post-test, there was a significant difference between groups, and the mean value of the PTG group was higher than that of the CG group. Our results are consistent with those of several previous studies. These studies have shown that polarized training is more effective in improving aerobic capacity(Carnes & Mahoney, 2019; Hebisz et al., 2021; Hebisz & Hebisz, 2024; Rosenblat et al., 2019; Silva Oliveira et al., 2024). Previous studies have shown that polarized training is more effective than traditional moderate-intensity training in improving maximal oxygen uptake (VO_2max). The improvement in endurance performance assessed by the Yo-Yo IR1 test was significantly greater in the polarized training group than in the moderate-intensity training group. This can be attributed to the unique advantage of the high/low intensity combination in polarized training, which has a significant advantage in stimulating endurance-related physiological adaptations. These findings are consistent with a large body of literature confirming the effectiveness of polarized training in enhancing aerobic capacity.

800-meter test and 1500-meter test

The study found that through a 6-week microcycle polarization comparison experiment, all athletes participating in the training improved their running performance, and the difference between the two groups at each time was not large. This indicates that polarization training has a significant impact on enhancing middle- and long-distance running performance in microcycle training; however, the difference between the groups is not statistically significant.

Both 800m and 1500m need to rely on the phosphocreatine system (ATP-CP) (short-term burst), glycolysis system (mid-stage maintenance), and aerobic system (long-distance support) at the same time, but the dominant systems are different. The anaerobic energy supply accounts for a higher proportion of 800m, and the aerobic energy supply only needs to reach 30% to provide stronger lactic acid resistance; 1500m relies more on the aerobic endurance foundation to support continuous output, and the aerobic demand needs to reach more than 50%.

This can be explained by the fact that both 800-meters and 1500-meters are mixed energy events (Fujii et al., 2012), which require the optimization of all three energy supply systems. The moderate intensity training of the control group is sufficient to stimulate the short-term adaptation of glycolysis and aerobic systems (Holm & Olsson, 2016). Any structured training (including the moderate intensity training of the control group) may improve the efficiency of mixed energy supply, resulting in no significant difference between the groups. Middle-distance events like the 800m and 1500m are special because they rely on both aerobic and anaerobic systems. About 70% of the energy in the 800m run comes from anaerobic metabolism, while about 50% of the energy in the 1500m run comes from aerobic metabolism and 50% from anaerobic metabolism (Akhmatov & Kabilova, 2024). This means that although the moderate-intensity training in the control group may be inefficient from a polarized training perspective, it can stimulate short-term improvements in physiological capacity that are directly related to anaerobic endurance in middle-distance events. This effect is similar to the effect produced by the high/low intensity combination in the polarized group (Muñoz et al., 2014). However, our results confirm previous research and show that incorporating polarized training into training programs has potential effectiveness, which may become an advantage in long-term training. However, in terms of efficiency, the polarized training group has a slightly higher efficiency than the CG group, so if the length of the training period is increased, it may be possible to obtain similar conclusions as(Muñoz et al., 2014).

POMS

In terms of emotional states, as measured by the POMS questionnaire, the results showed that the average score of athletes who received polarized training was lower than that of the conventional training group. This can be explained by the fact that polarized training significantly optimizes the physiological and psychological perception of athletes through polarization of high and low intensities and strict control of moderate intensity. Low-intensity training promotes recovery and metabolic efficiency, while high-intensity training enhances athletic performance and reduces fatigue. This pattern can reduce muscle soreness, joint stress, and fatigue (Pla et al., 2019). Except for the ERA factor score of PTG being higher than that of CG and the fatigue factor being equal between the two groups, the scores of other factors were all higher in the CG group than in the PTG group. This shows that polarized training is beneficial to the recovery of athletes' fatigue, which is similar to the conclusion of (Seiler, 2010) on a 12-week experiment on 20 middle- and long-distance runners. This shows that low-intensity training promotes recovery and reduces cumulative fatigue. In addition, polarized training can reduce the degree of depression in athletes. This shows the impact of the "relaxation effect" of low-intensity training on athletes. Polarized training makes it easier for athletes to master the training rhythm because of the clear load distribution. The POMS "confusion" score is significantly lower than that of ordinary training. From the seventh dimension, a high score means that polarized training can effectively improve athletes' confidence, which is similar to the conclusion of (Larsen & Diener, 1987). This shows that planned training enhances athletes' sense of self-efficacy and the "challenge" of high-intensity training.

Discussion Summary

Overall, the analysis showed that polarized microcycle training can improve the athletic ability of amateur middle- and long-distance runners. The training results showed that polarized microcycle training can maximize the accumulation of lactic acid in the body, prompting the body to maintain a dynamic balance between rapid lactic acid production and rapid lactic acid elimination, and improve the athletes' VO_2max. However, although the training program did not differ from the control group (moderate-intensity training), polarized training showed an improvement trend in multiple parameters. Therefore, polarized training programs may significantly improve the aerobic capacity of amateur middle- and long-distance runners. Second, this indicates that polarization training has a significant impact on enhancing middle- and long-distance running performance in microcycle training; however, the difference between the groups is not statistically significant. Third, microcycle polarization training has significant advantages in affecting athletes' psychology. The POMS results showed that polarized training can better reduce athletes' negative emotions, stimulate athletes' pride, and effectively relieve athletes' fatigue. Through the comparison of POMS data, physical training was found to systematically optimize the athletes' mental state through physiological and psychological dual intervention, regulating hormone levels and enhancing neuromuscular adaptability from the sports physiological level. The psychological level could enhance self-efficacy and reduce the risk of emotional exhaustion. The key to PTG's significant superiority over the control group lies in the scientific nature of the training plan, the integration of the recovery strategy, and the real-time psychological monitoring, which provides empirical evidence for psychological training in competitive sports.

Conclusion

This study focused on amateur middle- and long-distance runners, who are different from professional middle- and long-distance runners. Professional athletes are high-level endurance athletes with high VO_2 max levels. A large amount of low-intensity training (HIIT) can improve the body's peripheral adaptation, thereby improving VO_2 max. However, the central adaptation capacity (oxygen transport capacity, such as heart size and hemoglobin volume) of amateur middle- and long-distance runners has not yet reached its limit, which may limit the central adaptation capacity, and HVLIT cannot have a great effect on their VO_2 max. However, the data from this experiment show that polarized training in microcycles can also improve the VO_2 max level of amateur middle- and long-distance runners. Through microcycle polarized training, the maximum oxygen uptake is improved, thereby improving the performance of athletes. After the VO_2 max is improved, aerobic metabolism can be used more effectively to replenish energy in the 800-meter exercise, delaying muscle fatigue and nerve fatigue caused by the accumulation of glycolysis products (such as lactic acid), thereby reducing pace fluctuations to improve performance. Training increases muscle endurance and neuromuscular coordination, and in the 1500-meter exercise, athletes can use energy more efficiently while running.

The alternating high-intensity and low-intensity training mode gives athletes more room to recover from fatigue, reduces sports fatigue, and reduces the psychological pressure brought by sports, reducing athletes' depression. High-intensity training can bring positive emotions to athletes in dimensions such as pride.

Overall, this study proves that microcycle polarization training has a significant effect on improving the maximum oxygen uptake of amateur athletes. Polarization training can improve athletes' middle and long-distance running performance, reduce sports fatigue, and have a positive impact on athletes' psychology.

Application of research results

The experimental results showed that planned training could improve the performance and VO_2 max level of amateur middle- and long-distance runners and enthusiasts. The research results provide a scientific basis for the training of amateur middle- and long-distance runners, which helps to choose more effective training methods to improve physical performance. The advantages of polarized training methods were popularized for coaches and athletes in places such as amateur marathons and middle- and long-distance running clubs, and applied to training to improve the overall performance of middle- and long-distance running. This program is suitable for the initial stage of physical fitness improvement for amateur middle- and long-distance runners, in which the participants have a low oxygen uptake base and can achieve the greatest improvement through polarized training, making the physical training program stand out, which is consistent with other variables obtained in the study.

Limitations

The limitation of this study, firstly, although the data of maximum oxygen uptake, middle- and long-distance running performance, and POMS were obtained through the experiment, other important variables in polarized training, such as changes in lactate values and running economy, are still missing, so the conclusion is not comprehensive. the selection of subjects in the study has regional and gender limitations.

Secondly, the experimental plan in the study was 6 weeks, and each training cycle was 3 weeks. The results obtained from other studies with longer training periods were slightly different. Perhaps in the future, more scientific conclusions can be obtained by lengthening the training period.

Third, the Xiaomi wristband was used in the study, and no medical collection instruments related to sports physiology were used. The data monitoring was not very professional.

Suggestions

1. Although this study found that polarized training and 6-week training of amateur middle- and long-distance runners have changes in VO_2 max, the subjects were tested for only 6 weeks, and each stage was short. If the test period is extended, whether the same result is obtained, further research and verification are needed.

2. Due to the limitations of experimental instruments and personnel, this study did not conduct relevant tests on more indicators. In the future, the study of polarized training can select relevant factors such as the respiratory system, cardiovascular system, and the ability of muscles to use oxygen for research.

REFERENCES

Akhmatov, J., & Kabilova, D. (2024). Speed endurance (middle distance). *Modern Science and Research*, *3*(2), 9–12.

Albrecht, R. R., & Ewing, S. J. (1989). Standardizing the administration of the Profile of Mood States (POMS): Development of alternative word lists. *Journal of Personality Assessment*, *53*(1), 31–39.

Arief, N. A., Supriyanto, C., Triardhana, Y. A., Hamdani, H., & Ayubi, N. (2024). Effect of High Volume Intensity Training and Polarized Training on Aerobic Endurance and Anaerobic Capacity in Intermittent Sports.

Arief, N. A., Supriyanto, C., Triardhana, Y. A., Hamdani, H., & Ayubi, N. (2025). Effect of High Volume Intensity Training and Polarized Training on Aerobic Endurance and Anaerobic Capacity in Intermittent Sports. Proceedings of the International Seminar of Sport and Exercise Science (ISSES 2024),

Bangsbo, J., Iaia, F. M., & Krustrup, P. (2008). The Yo-Yo intermittent recovery test: a useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine*, *38*, 37–51.

Bassett, D. R., & Howley, E. T. (2000). Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Medicine and science in sports and exercise*, *32*(1), 70–84.

Bompa, T., & Buzzichelli, C. (2015). *Periodization training for sports, 3e*. Human kinetics.

Bourgeois, A., LeUnes, A., & Meyers, M. (2010). Full-scale and short-form of the profile of mood states: a factor analytic comparison. *Journal of Sport Behavior*, *33*(4).

Burnley, M., Bearden, S. E., & Jones, A. M. (2022a). Polarized training is not optimal for endurance athletes. *Med Sci Sports Exerc*, *54*(6), 1032–1034.

Burnley, M., Bearden, S. E., & Jones, A. M. (2022b). Polarized training is not optimal for endurance athletes.

Carnes, A. J., & Mahoney, S. E. (2019). Polarized versus high-intensity multimodal training in recreational runners. *International journal of sports physiology and* *performance*, *14*(1), 105–112.

Fujii, N., Ogawa, T., Ichinose, M., Hayashi, K., & Nishiyasu, T. (2012). 800-m and 1500-m run times relate to anaerobic performance in competitive runners. *Gazz Med Ital-Arch Sci Med*, *171*, 491–501.

González-Mohíno, F., González-Ravé, J. M., Juárez, D., Fernández, F. A., Castellanos, R. B., & Newton, R. U. (2016). Effects of continuous and interval training on running economy, maximal aerobic speed and gait kinematics in recreational runners. *The Journal of Strength & Conditioning Research*, *30*(4), 1059–1066.

Grove, J. R., & Prapavessis, H. (1992). Preliminary evidence for the reliability and validity of an abbreviated profile of mood states. *International Journal of Sport Psychology*.

Grove, R., & Prapavessis, H. (2016). *Abbreviated POMS Questionnaire (items and scoring key)* (

Haff, G. G. (2013). Periodization strategies for youth development. In *Strength and Conditioning for Young Athletes* (pp. 171–190). Routledge.

Hebisz, P., Hebisz, R., & Drelak, M. (2021). Comparison of aerobic capacity changes as a result of a polarized or block training program among trained mountain bike cyclists. *International journal of environmental research and public health*, *18*(16), 8865.

Hebisz, R., & Hebisz, P. (2024). Biseasonal Changes in Aerobic Capacity and Sports Performance in Highly Trained Mountain Bike Cyclists Applying Elements of the Polarized Training Programme. *Polish Journal of Sport and Tourism*, *31*(2), 17–25.

Holm, I., & Olsson, K. (2016). Energiomsättning under 800-meterslöpning: En experimentell studie om relationen mellan anaerob och aerob energiomsättning. In.

Hydren, J. R., & Cohen, B. S. (2015). Current scientific evidence for a polarized cardiovascular endurance training model. *The Journal of Strength & Conditioning Research*, *29*(12), 3523–3530.

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Pedersen, P. K., & Bangsbo, J. (2003). The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Medicine & Science in Sports & Exercise*, *35*(4), 697–705.

Lane, A. M., Devonport, T. J., Stanley, D., & Beedie, C. J. (2016a). The effects of brief online self-help intervention strategies on emotions and satisfaction with running performance. *Sensoria: A Journal of Mind, Brain & Culture*, *12*(2), 30–39.

Lane, A. M., Devonport, T. J., Stanley, D., & Beedie, C. J. (2016b). The effects of brief online self-help intervention strategies on emotions and satisfaction with running performance. *Sensoria J Mind Brain Culture*, *12*, 30–39.

Larsen, R. J., & Diener, E. (1987). Affect intensity as an individual difference characteristic: A review. *Journal of Research in personality*, *21*(1), 1–39.

Lochbaum, M., Zanatta, T., Kirschling, D., & May, E. (2021). The Profile of Moods States and athletic performance: A meta-analysis of published studies. *European journal of investigation in health, psychology and education*, *11*(1).

Martin, J. J., & Gill, D. L. (1995). The relationships of competitive orientations and self-efficacy to goal importance, thoughts, and performance in high school distance runners. *Journal of Applied Sport Psychology*, *7*(1), 50–62.

Muñoz, I., Seiler, S., Bautista, J., España, J., Larumbe, E., & Esteve-Lanao, J. (2014). Does polarized training improve performance in recreational runners? *International journal of sports physiology and performance*, *9*(2), 265–272.

Nøst, H. L., Aune, M. A., & van den Tillaar, R. (2024). The Effect of Polarized Training Intensity Distribution on Maximal Oxygen Uptake and Work Economy Among Endurance Athletes: A Systematic Review. *Sports*, *12*(12), 326.

Pang, L., Xie, X., & Lin, Y. (2023). POMS and eye movement: Two indicators for performance in athletics. *Heliyon*, *9*(7).

Pla, R., Le Meur, Y., Aubry, A., Toussaint, J.-F., & Hellard, P. (2019). Effects of a 6-week period of polarized or threshold training on performance and fatigue in elite swimmers. *International journal of sports physiology and performance*, *14*(2), 183–189.

Prapavessis, H., & Grove, J. R. (1991). Precompetitive emotions and shooting performance: The mental health and zone of optimal function models. *The Sport*

Psychologist, *5*(3), 223–234.

Rivera-Köfler, T., Varela-Sanz, A., Padron-Cabo, A., Giráldez-García, M. A., & Munoz-Perez, I. (2025). Effects of Polarized Training vs. Other Training Intensity Distribution Models on Physiological Variables and Endurance Performance in Different-Level Endurance Athletes: A Scoping Review. *The Journal of Strength & Conditioning Research*, *39*(3), 373–385.

Rivera-Köfler, T., Varela-Sanz, A., Padron-Cabo, A., Giráldez-García, M. A., & Muñoz-Pérez, I. (2022). Effects of Polarized Training vs. Other Training Intensity Distribution Models on Physiological Variables and Endurance Performance in Different-Level Endurance Athletes: A Scoping Review. *The Journal of Strength & Conditioning Research*, 10.1519.

Rosenblat, M. A., Perrotta, A. S., & Vicenzino, B. (2019). Polarized vs. threshold training intensity distribution on endurance sport performance: a systematic review and meta-analysis of randomized controlled trials. *The Journal of Strength & Conditioning Research*, *33*(12), 3491–3500.

Seiler, S. (2010). What is best practice for training intensity and duration distribution in endurance athletes? *International journal of sports physiology and performance*, *5*(3), 276–291.

Shi, Q.-y. (2023). *Research on the influence of sports bracelet monitoring on Physical training effect of high school female basketball Players* Shanxi University].

Silva Oliveira, P., Boppre, G., & Fonseca, H. (2024). Comparison of polarized versus other types of endurance training intensity distribution on athletes' endurance performance: a systematic review with meta-analysis. *Sports Medicine*, *54*(8), 2071–2095.

Stöggl, T., & Sperlich, B. (2014). Polarized training has greater impact on key endurance variables than threshold, high intensity, or high volume training. *Frontiers in physiology*, *5*, 33.

Stöggl, T. L., & Sperlich, B. (2015). The training intensity distribution among well-trained and elite endurance athletes. *Frontiers in physiology*, *6*, 295.

Treff, G., Winkert, K., Sareban, M., Steinacker, J. M., & Sperlich, B. (2019). The polarization-index: a simple calculation to distinguish polarized from non-polarized training intensity distributions. *Frontiers in physiology*, *10*, 707.

West, G. B., Brown, J. H., & Enquist, B. J. (1997). A general model for the origin of allometric scaling laws in biology. *Science*, *276*(5309), 122–126.

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