RESEARCH PAPER

Differences in The Effects of Specific Preparation-Phase Training and Conventional Training on Lactate Levels and Basic Physical Abilities in Karate Athletes

Aprinaldi[1*], Ambrosius Purba[2], Leonardo Lubis[3], Yuni Susanti Pratiwi[4], Yetty Machrina[5]

[1*] Doctoral Program, Faculty of Medicine, Universitas Padjadjaran.
Email: aprinaldiap12@gmail.com (Corresponding Author)
[2,4] Department of Physiology, Faculty of Medicine, Universitas Padjadjaran.
Email: profpurba05@gmail.com, yunilazuardi@gmail.com
[3] Department of Anatomy, Faculty of Medicine, Universitas Padjadjaran. Email: btpualam@gmail.com
[5] Department of Physiology, Faculty of Medicine, Universitas Sumatera Utara. Email: yetty@usu.ac.id

Received: 2nd Mar, 2026 | **Revised:** 14th Mar, 2026 | **Accepted:** 4th Apr, 2026 | **Available Online:** 20th Apr, 2026

ABSTRACT

Karate is an official sport competed at the regional, national, and international levels. The Padang Pariaman Regency Sports Council (KONI) in West Sumatra also sent karate athletes to the PORPROV event; however, they have never won a medal during the West Sumatra PORPROV. Similarly, the Karate athletes selected through the West Sumatra PORPROV who participated in the 2016 XIX PON in West Java were unable to win any medals. This failure may be due to the coaches' failure to apply Sport Science in their training programs based on the FITT formula (F=Frequency of Training, I=Intensity/Dose of Training, T=Time/Duration of Training, T=Type of Training). In light of this, a study was conducted on the differences in the effects of Specialized Preparation Phase Training versus Conventional Training on Lactate Levels and Basic Physical Performance Components in Karate Athletes, namely: Lower Limb Muscle Strength, Abdominal Muscle Endurance, Shoulder Muscle Endurance, Lower Limb Muscle Endurance, Lower Limb Muscle Power, Upper Limb Muscle Power, Flexibility, and Agility. This study is an experimental study using a randomized pre- and post-test control group design. It analyzes changes in the basic physical abilities of karateka following a specialized preparatory training program. The results of the study showed that, based on the Mann-Whitney U test ($p < 0.05$), lactate levels in karate athletes who underwent the Special Preparation Phase Training were lower than those in athletes who underwent Conventional Training (53.10 ± 1.10 vs. 84.41 ± 2.27 mmol/L). Using an unpaired t-test ($p < 0.05$), it was found that lower limb muscle strength in karate athletes who underwent the Special Preparation Phase Training was greater than that in athletes who underwent Conventional Training (197.00 ± 12.44 vs 77.33 ± 1.66; $p < 0.01$). Using an unpaired t-test ($p < 0.05$), it was also found that abdominal muscle endurance in the group receiving the Special Preparation Phase Training was better than that in the group receiving Conventional Training among Karate Athletes (46.60 ± 2.22 vs. 33.75 ± 1.54, $p < 0.001$). Furthermore, it was found that shoulder muscle endurance in karate athletes who underwent the Special Preparation Phase training was better than that of those who underwent conventional training (49.20 ± 1.68 vs. 33.75 ± 2.76, $p < 0.001$). Using an unpaired t-test ($p < 0.05$), it was found that lower limb muscle endurance in karate athletes who underwent Specialized Preparation Training was superior to that of athletes who underwent Conventional Training (48.90 ± 3.75 vs. 29.00 ± 1.04, $p < 0.001$). Results of the unpaired t-test ($p < 0.05$) showed that lower limb muscle power in athletes who underwent conventional training was better than that in athletes who underwent special preparatory training (54.10 ± 2.42 vs. 39.25 ± 0.86, $p < 0.001$). Results of the analysis using an unpaired t-test ($p < 0.05$) also showed that the upper limb muscle power of karate athletes who underwent the Special Preparation Phase training was better than that of those who underwent conventional training (39.80 ± 2.78 vs. 34.16 ± 2.62, $p < 0.001$). Results of the analysis using an unpaired t-test ($p<0.05$) showed that flexibility in karate athletes who underwent Special Preparation Phase Training was better than in those who underwent Conventional Training (32.50 ± 1.64 vs 31.41 ± 2.46, $p<0.001$). The results of the analysis of using an unpaired t-test (p <

0.05) showed that agility in the group receiving conventional training was better than that in the group receiving Special Preparation Phase training among karate athletes (38.70 ± 1.15 vs. 32.95 ± 5.52, $p < 0.001$).
Conclusion: The results of this study indicate that the basic physical abilities of karate athletes improved after undergoing Special Preparation Phase Training.
Keywords: Karate Athletes, Basic Physical Components, Specific Preparation Phase Training.
How to cite this article: Aprinaldi, Purba A, Lubis L, Pratiwi YS, Machrina Y. Differences in The Effects of Specific Preparation-Phase Training and Conventional Training on Lactate Levels and Basic Physical Abilities in Karate Athletes. Int J Drug Deliv Technol. 2026;16(34s):607-618. DOI: 10.25258/ijddt.16.34s.76
Source of support: Nil.
Conflict of interest: The authors declare no conflict of interest.

INTRODUCTION

Karate is a modern martial art rooted in traditional Japanese martial arts. The sport of Karate consists of Kihon (Fundamentals), Kata (Forms), and Kumite (Sparring). Kihon refers to the basic movements of Karate, which include punches, kicks, and blocks. Kata is a series of movements performed by Karate Athletes using specific techniques that embody the harmony of martial arts. Currently, Kumite is contested between two people using specific techniques and strategies involving punching, kicking, and blocking movements, and these movements require good physical condition to win the match.1,2,3

Karate is an official sport competed at the regional, national, and international levels. At the regional level, karate is contested at various Regional Sports Weeks (Porda). At the national level, karate is contested at the National Sports Week (PON), which is participated in by karate teams representing each province. At the international level, karate is contested at the World Karate Championships (WKF), the SEA Games, the Asian Games, and other tournaments.

Karate athletes from West Sumatra Province are being prepared to compete in the National Sports Week (PON) in Papua in 2021. The West Sumatra karate athletes who will compete in Papua in 2021 were first selected through the West Sumatra Provincial Sports Week (PORPROV). At the PORPROV event, every city and regency in West Sumatra sent their respective karate athletes to participate in the PORPROV Championship. Similarly, the Indonesian National Sports Committee (KONI) of Padang Pariaman Regency, West Sumatra, also sent karate athletes to the PORPROV event; however, during the West Sumatra PORPROV, they have never won a medal. Likewise, the karate athletes selected through the West Sumatra PORPROV who participated in the 19th PON in West Java in 2016 failed to win a medal. Similarly, at the World Karate Championships (WKF) held at the Wizink Center in Madrid, Spain, in November 2018, Indonesian karate athletes failed to win a gold medal. Based on the preceding discussion, Indonesian karate athletes have not achieved success at the regional, national, or international levels, likely due to the suboptimal application of Sport Science or Exercise Science within the training periodization program. The application of Sport Science by coaches in training programs based on the FITT formula (F=Training Frequency, I=Training Intensity/Dose, T=Time/Duration of Training, T=Type of Training) must be strictly implemented so that athletes can achieve peak performance. The suboptimal performance of Indonesian Karate athletes is likely due to training programs that remain conventional and have not yet applied Sports Science based on Exercise Physiology. Indonesian karate coaches, when implementing training programs for athletes, always rely on their own experiences from when they were athletes. Coaches in Indonesia have relatively limited understanding of the application of sports science or are reluctant to apply sports physiology because they are accustomed to implementing training programs based on what they experienced during their own athletic careers.4-6

Recently, developed countries have been implementing sports science by applying exercise physiology to athlete training programs, particularly for karate athletes. The application of exercise physiology serves as the foundation for determining training loads appropriate to the athletes' physical and physiological conditions, especially for karate athletes. Well-measured and properly programmed training loads can improve athletes' physical condition, particularly that of karate athletes. Training loads that are too heavy can lead to injury, while light training loads are ineffective for improving an athlete's physical condition. This conventional training program may be the reason why athletes from West Sumatra are unable to perform at their best due to suboptimal physical condition.4-6

Karate athletes in good physical condition will find it easier to understand techniques and apply strategies during matches, such as countering sudden attacks from opponents using Kata and Kihon. In competition, karate athletes require optimal physical condition to execute numerous attacks—including punches and kicks—against their opponents, which is crucial for their victory. The number of successful Ippon and Sampon attacks will determine whether a karate athlete wins a medal. To perform relatively difficult movements, karate athletes must possess optimal physical condition.1,2,4-6

In accordance with the movement patterns of karate athletes during competition, in order to achieve maximum performance, they must also possess optimal basic physical components, namely: upper body, lower body, and back strength; core, shoulder, and lower body endurance; lower body and upper body explosive power; flexibility; general endurance; and agility. The suboptimal performance of West Sumatra Karate Athletes and Indonesian Karate Athletes is likely due to the suboptimal Basic Physical Components of Karate Athletes and the lack of application of Sport Science or Exercise Physiology in the Training Periodization Program.5-7

Based on the movement patterns characteristic of karate athletes' physical activity, both during training and competition, energy is derived from aerobic metabolism and lactacid anaerobic metabolism. During high-intensity physical activity in karate athletes—such as during training or competition—the energy source comes from lactate-based anaerobic metabolism, which produces lactic acid. The accumulation of lactic acid in the muscles can cause muscle soreness and a decrease in pH within the muscle sarcoplasm; this condition impairs the athlete's physical performance, and both factors can reduce the athlete's performance. An increase in lactate levels causes a decrease in muscle pH, thereby accelerating the onset of fatigue. The decrease in pH disrupts the production of energy/ATP required by Karate athletes during training or competition; therefore, efforts must be made to eliminate the negative effects of lactate on the physical condition of Karate athletes, and such efforts can be achieved by applying Sports Science to the Training Periodization Program.4,8-13

Based on the background of the problem described above, this study investigated: The differences in the effects of Specialized Preparation Training versus Conventional Training on Lactate Levels and Basic Physical Performance Components in Karate Athletes: Lower Limb Muscle Strength, Abdominal Muscle Endurance, Shoulder Muscle Endurance, Lower Limb Muscle Endurance, Lower Limb Muscle Power, Upper Limb Muscle Power, Flexibility, and Agility.

RESEARCH METHOD

Research Design

This study is an experimental study using a randomized pre- and post-test control group design. This study analyzed changes in the physical fitness of karateka as measured by the " " test, specifically focusing on the following components: lower body muscle strength, abdominal muscle endurance, shoulder muscle endurance, lower body muscle endurance, lower body muscle power, upper body muscle power, flexibility, and agility, as well as changes in blood lactate levels. Lactic acid is a product of anaerobic lactate metabolism that forms during Special Preparation Phase (SPP) training.[25]

This experimental study was conducted in the field, with treatments administered and treatment responses analyzed both in the field and in the laboratory, as shown in Figure 3.1.

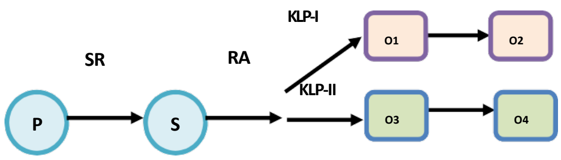

Figure 1. Schematic of the Experimental Randomized Pre- and Post-Test Group Design

Research Location and Time

The study was conducted in Padang Pariaman, West Sumatra. The study period ran from August 2022 to December 2022. The study consisted of a preparation phase, with the entire process—from the start to the end of the study—taking eight weeks. The duration of this study is closely related to the findings of physiological experts, who indicate that the effects of resistance training are optimal for improving muscle capacity: after 2 weeks, muscle capacity increases by 10%; after 4 weeks, it increases by 20%; and after 8–10 weeks, it increases by 30%. while cardiorespiratory endurance will increase significantly after 4–6 weeks of training/intervention.40

Research Population and Subjects

The target population of this study consists of 50 karateka from a club located in Pariaman, Padang, West Sumatra. Thirty participants were then randomly selected and divided into two groups: KLP-I: the treatment group, consisting of 15 participants who received conventional training; and KLP-II: the group that received special preparatory training, consisting of 15 participants (the sample size was determined based on statistical calculations). Before participating in the training, the research subjects underwent a health examination by a doctor.

Notes:
P: Study Population
SR: Sample Randomization
S: Sample
RA: Random allocation to receive different treatments, namely Conventional Training and Special Karateka Preparation Training
KLP-I: Conventional Training Group (KLP-I = control group) Karateka
KLP-II: Special Preparation Training Group (KLP-II) Karateka
O1: Pre-test for KLP-I participants who received conventional training
O2: Post-Test for KLP-I participants who received conventional karate training
O3: Pre-test for KLP-II participants who received Special Preparation Phase training
O4: Post-Test for KLP-II karateka who received Special Preparation Phase Training

Data Analysis

Data were analyzed using SPSS version 22 with a significance level of $p<0.05$, following these steps:

1. Data are presented in the form of tables and diagrams.
2. Homogeneity test using Levene's test ($p > 0.05$)
3. Data normality test using the Kolmogorov-Smirnov test ($p > 0.05$)
4. If the data are normally distributed, a paired t-test ($p < 0.05$) is performed to determine the effect of the treatment, and an unpaired t-test ($p < 0.05$) is performed to compare the effects of the two groups.

If the data are not normally distributed, the Kruskal-Wallis test ($p < 0.05$) is used to determine the effect of the treatment, and the Mann-Whitney test ($p < 0.05$) is used to determine the difference in effects between the two groups.

RESULTS AND DISCUSSION

Research Results

Physical and Physiological Characteristics of Karate Athletes

The physical and physiological characteristics of karate athletes in the Special Preparation Training Group and the Conventional Training Group, including gender, age (years), height (cm), body weight (kg), and blood pressure (mmHg), are listed in Table 4.1.

Table 1. Physical and Physiological Characteristics of Karate Athletes in the Special Preparation Phase Training Group and the Conventional Training Group (n=22)a

No.	Characteristics	Group		p-value
		Exercise Stage Special Preparation (n = 10)	Exercise Conventional (n = 12)	
1	**Gender**			0.045
	Male	10	12	
	Female	0	0	
2	**Age (years)**			0.035
	Mean (SD)	19	19	
	Range	18–20	18–20	
3	**Height**			0.249
	Average (SD)	162.4	162.4	
	Range	152–168	152–168	
4	**Body Weight**			0.881
	Mean (SD)	54.17	54.17	
	Range	52–57	52–57	
5	**Systolic (mmHg)**			0.025
	Mean (SD)	112.92	112.92	
	Range	100–120	100–120	
6	**Diastolic (mmHg)**			0.035
	Mean (SD)	76.67	76.67	
	Range	70–80	70–80	

**Unpaired t-test (p > 0.05)*

The physical-physiological characteristics were relatively similar in both groups, namely the karate athletes who received Special Preparation

Phase Training and those who received Conventional Training.

Tests of Normality and Homogeneity of Research Data

Normality Test of Research Data on Lactic Acid, Lower Limb Muscle Strength, Abdominal Muscle Endurance, Shoulder Muscle Endurance, Lower Limb Muscle Endurance, Lower Limb Muscle Power, Upper Limb Muscle Power, Flexibility and Agility in Karate Athletes in the Special Preparation Training Group and the Conventional Training Group were analyzed using the Kolmogorov-Smirnov test ($p > 0.05$). The analysis results indicate that the data are normally distributed; the complete analysis results are listed in Appendix 4.1.

The Levene's test for homogeneity ($p > 0.05$) showed that the research data on Lactic Acid, Lower Limb Muscle Strength, Abdominal Muscle Endurance, Shoulder Muscle Endurance, Lower Limb Muscle Endurance, Lower Limb Muscle Power, Upper Limb Muscle Power, Flexibility, and Agility in Karate Athletes in the Special Preparation Training Group and the Conventional Training Group are homogeneous; the complete analysis results are described in Appendix 4.1.

Differences in the Effect on Lactate Levels

To analyze the effect of the Special Preparation Phase Training on lactate levels, a paired t-test ($p < 0.05$) was conducted because the data were normally distributed. The results of the paired t-test showed a highly significant increase in lactate levels in karate athletes after undergoing the Special Preparation Phase Training (27.30 ± 0.82 vs. 53.10 ± 1.10 m; $p < 0.001$). The increase in lactate was 52.83%. The complete analysis results are listed in Table 4.2.

To analyze the effect of Conventional Training on lactate levels, a paired t-test ($p < 0.05$) was performed because the data were normally distributed. The results of the paired t-test showed a highly significant increase in karate athletes after undergoing Conventional Training (25.91 ± 2.10 vs 84.41 ± 2.27 m; $p<0.001$). The increase in lactate levels was 84.15%. The complete analysis results are listed in Table 4.2.

The results of the unpaired t-test ($p < 0.05$) showed that lactate levels in the Special Preparation Phase training group were lower than those in the Conventional Training group among karate athletes (53.10 ± 1.10 vs. 84.41 ± 2.27 mmol/L).

Table 2. Effect of Specialized Preparation Phase Training and Conventional Training on Lactate Levels in Karate Athletes (n=22)

Type of Training	n	Pre (Mean ± SD)	Post (Mean ± SD)	p
Special Preparation Phase	10	27.30 ± 0.82	53.10 ± 1.10	p < 0.001
Conventional	12	25.91 ± 2.10	84.41 ± 2.27	p < 0.001

Note: Paired t-test used (p < 0.05)

Differences in the Effect on Lower Limb Muscle Strength

To analyze the effect of the Special Preparation Phase Training on lower limb muscle strength, a paired t-test ($p < 0.05$) was conducted because the data were normally distributed. The results of the paired t-test showed a highly significant increase in lower limb muscle strength in karate athletes after undergoing the Special Preparation Phase Training (76.40 ± 2.79 vs. 197.00 ± 12.44; $p < 0.001$). The increase in lower limb muscle strength was 120%. The complete analysis results are listed in Table 4.3.

To analyze the effect of Conventional Training on lower limb muscle strength, a paired t-test ($p < 0.05$) was conducted because the data were normally distributed. The results of the paired t-test showed an increase in lower limb muscle strength in karate athletes after undergoing Conventional Training (73.58 ± 3.23 vs. 77.33 ± 1.66; $p < 0.001$). The increase in lower limb muscle strength was 0.03%. The complete analysis results are listed in Table 4.3.

The results of the unpaired t-test ($p < 0.05$) showed that the lower limb muscle strength of karate athletes who underwent the Special Preparation Phase training was greater than that of athletes who underwent conventional training (197.00 ± 12.44 vs. 77.33 ± 1.66; $p < 0.01$).

Table 3. The Effect of Special Preparation Phase Training and Conventional Training on Lower Limb Muscle Strength in Karate Athletes (n=22)

Type of Training	n	Pre (Mean ± SD)	Post (Mean ± SD)	p
Special Preparation Phase	10	76.40 ± 2.79	197.00 ± 12.44	p < 0.001
Conventional	12	73.58 ± 3.23	77.33 ± 1.66	p < 0.001

Note: Paired t-test used (p < 0.05)

Differences in the Effect on Abdominal Muscle Endurance

To analyze the effect of the Special Preparation Phase Training on abdominal muscle endurance, a paired t-test (p < 0.05) was conducted because the data were normally distributed. The results of the paired t-test showed a highly significant increase in abdominal muscle endurance in karate athletes after undergoing the Special Preparation Phase Training (32.10 ± 2.55 vs. 46.60 ± 2.22; p < 0.001). The increase in abdominal muscle endurance was 14.50%. The complete analysis results are presented in Table 4.4.

To analyze the effect of Conventional Training on abdominal muscle endurance, a paired t-test (p < 0.05) was conducted because the data were normally distributed. The results of the paired t-test showed an increase in abdominal muscle endurance in karate athletes after undergoing Conventional Training (26.58 ± 1.44 vs. 33.75 ± 1.54; p < 0.001). The increase in abdominal muscle endurance was 7.17%. The complete analysis results are listed in Table 4.4.

Results of the unpaired t-test (p < 0.05) revealed that abdominal muscle endurance in karate athletes who underwent Special Preparation Phase Training was superior to that of athletes who underwent Conventional Training (46.60 ± 2.22 vs. 33.75 ± 1.54, p < 0.001).

Table 4. The Effect of Special Preparation Phase Training and Conventional Training on Abdominal Muscle Endurance in Karate Athletes (n=22)

Type of Training	n	Pre (Mean ± SD)	Post (Mean ± SD)	p
Special Preparation Phase	10	32.10 ± 2.55	46.60 ± 2.22	p < 0.001
Conventional	12	26.58 ± 1.44	33.75 ± 1.54	p < 0.001

Note: Paired t-test used (p < 0.05)

Differences in the Effect on Shoulder Muscle Endurance

To analyze the effect of the Special Preparation Phase Training on shoulder muscle endurance, a paired t-test (p < 0.05) was performed because the data were normally distributed. The results of the paired t-test showed a highly significant increase in shoulder muscle endurance in karate athletes after undergoing the Special Preparation Phase Training (27.90 ± 0.99 vs. 49.20 ± 1.68; p < 0.001). The increase in shoulder muscle endurance was 21.30%. The complete analysis results are listed in Table 4.5.

To analyze the effect of conventional training on shoulder muscle endurance, a paired t-test (p < 0.05) was conducted because the data were normally distributed. The results of the paired t-test showed an increase in shoulder muscle endurance in karate athletes after undergoing Conventional Training (27.91 ± 0.99 vs 33.75 ± 2.76; p < 0.001). The increase in shoulder muscle endurance was 5.84%. The complete analysis results are listed in Table 4.5.

Results of the unpaired t-test (p < 0.05) revealed that shoulder muscle endurance in karate athletes who received the Special Preparation Phase Training was superior to that of athletes who received Conventional Training (49.20 ± 1.68 vs. 33.75 ± 2.76; p < 0.001).

Table 5. The Effect of Specialized Preparation Phase Training and Conventional Training on Shoulder Muscle Endurance in Karate Athletes (n=22)

Type of Training	n	Pre (Mean ± SD)	Post (Mean ± SD)	p
Special Preparation Phase	10	27.90 ± 0.99	49.20 ± 1.68	p < 0.001
Conventional	12	27.91 ± 0.99	33.75 ± 2.76	p < 0.001

Note: A paired t-test was used (p < 0.05)

Differences in the Effect on Lower Limb Muscle Endurance

To analyze the effect of the Special Preparation Phase Training on lower limb muscle endurance, a paired t-test ($p<0.05$) was performed because the data were normally distributed. The results of the paired t-test showed a highly significant increase in lower limb muscle endurance in karate athletes after undergoing the Special Preparation Phase Training (23.80 ± 2.14 vs. 48.90 ± 3.75; $p < 0.001$). The increase in lower limb muscle endurance was 25.10%. The complete analysis results are presented in Table 4.6.

To analyze the effect of conventional training on lower-body muscle endurance, a paired t-test ($p < 0.05$) was conducted because the data were normally distributed. The results of the paired t-test showed an increase in lower limb muscle endurance in karate athletes after undergoing Conventional Training (22.58 ± 1.08 vs. 29.00 ± 1.04; $p < 0.001$). The increase in lower limb muscle endurance was 6.42%. The complete analysis results are listed in Table 4.6.

Results of the unpaired t-test ($p<0.05$) showed that leg muscle endurance in karate athletes who received the Special Preparation Phase Training was better than that of athletes who received Conventional Training (48.90 ± 3.75 vs 29.00 ± 1.04; $p<0.001$).

Table 6. The Effect of Special Preparation Phase Training and Conventional Training on Lower Limb Muscle Endurance in Karate Athletes (n=22)

Type of Training	n	Pre (Mean ± SD)	Post (Mean ± SD)	p
Special Preparation Phase	10	23.80 ± 2.14	48.90 ± 3.75	p < 0.001
Conventional	12	22.58 ± 1.08	29.00 ± 1.04	p < 0.001

Note: Paired t-test used ($p < 0.05$)

Differences in the Effect on Lower Limb Muscle Power

To analyze the effect of the Special Preparation Phase Training on lower limb muscle power, a paired t-test ($p < 0.05$) was performed because the data were normally distributed. The results of the paired t-test showed a highly significant increase in lower limb muscle power in karate athletes after undergoing Special Preparation Phase Training (35.66 ± 2.01 vs. 39.25 ± 0.86; $p < 0.001$). The complete analysis results are listed in Table 4.7.

To analyze the effect of conventional training on lower-body muscle power, a paired t-test ($p < 0.05$) was conducted because the data were normally distributed. The results of the paired t-test showed an increase in lower limb muscle power in karate athletes after receiving Conventional Training (37.60 ± 0.51 vs. 54.10 ± 2.42; $p < 0.001$). The complete analysis results are listed in Table 4.7.

Analysis using an unpaired t-test ($p < 0.05$) revealed that leg muscle power in athletes who received Conventional Training was superior to that in athletes who received Specialized Preparation Training (54.10 ± 2.42 vs. 39.25 ± 0.86; $p<0.001$).

Table 7. The Effect of Special Preparation Phase Training and Conventional Training on Lower Limb Muscle Power in Karate Athletes (n=22)

Type of Training	n	Pre (Mean ± SD)	Post (Mean ± SD)	p
Special Preparation Phase	10	35.66 ± 2.01	39.25 ± 0.86	p < 0.001
Conventional	12	37.60 ± 0.51	54.10 ± 2.42	p < 0.001

Note: Paired t-test used ($p < 0.05$)

Differences in the Effect on Arm Muscle Power

To analyze the effect of the Special Preparation Phase Training on improving arm muscle power, a paired t-test ($p < 0.05$) was performed because the data were normally distributed. The results of the paired t-test showed a highly significant increase in arm muscle power in karate athletes after undergoing Special Preparation Phase Training (31.30 ± 3.02 vs. 39.80 ± 2.78; $p < 0.001$). The complete analysis results are listed in Table 4.8.

To analyze the effect of conventional training on improving arm muscle power, a paired t-test ($p < 0.05$) was conducted because the data were normally distributed. The results of the paired t-test showed an increase in arm muscle power in karate athletes after undergoing Conventional Training

(22.41 ± 4.18 vs. 34.16 ± 2.62; p < 0.001). The complete analysis results are listed in Table 4.8.

Analysis using an unpaired t-test (p < 0.05) revealed that arm muscle power in karate athletes who underwent Specialized Preparation Training was superior to that of athletes who underwent Conventional Training (39.80 ± 2.78 vs. 34.16 ± 2.62; p < 0.001).

Table 8. The Effect of Special Preparation Phase Training and Conventional Training on Arm Muscle Explosive Strength in Karate Athletes (n=22)

Type of Training	n	Pre (Mean ± SD)	Post (Mean ± SD)	p
Special Preparation Phase	10	31.30 ± 3.02	39.80 ± 2.78	p < 0.001
Conventional	12	22.41 ± 4.18	34.16 ± 2.62	p < 0.001

Note: Paired t-test used (p < 0.05)

Differences in Effects on Flexibility

To analyze the effect of the Special Preparation Phase Training on flexibility, a paired t-test (p < 0.05) was performed because the data were normally distributed. The results of the paired t-test showed an increase in flexibility in karate athletes after undergoing Special Preparation Phase Training (23.30 ± 1.33 vs. 32.50 ± 1.64; p < 0.001). The complete analysis results are listed in Table 4.9.

To analyze the effect of Conventional Training on flexibility, a paired t-test (p < 0.05) was performed because the data were normally distributed. The results of the paired t-test showed an increase in flexibility in karate athletes after undergoing Conventional Training (19.91 ± 1.31 vs. 31.41 ± 2.46; p < 0.001). The complete analysis results are listed in Table 4.9.

The results of the unpaired t-test (p < 0.05) showed that flexibility in karate athletes who underwent the Special Preparation Phase training was better than that of athletes who underwent conventional training (32.50 ± 1.64 vs. 31.41 ± 2.46; p < 0.001).

Table 9. The Effect of Specialized Preparation Phase Training and Conventional Training on Flexibility in Karate Athletes (n=22)

Type of Training	n	Pre (Mean ± SD)	Post (Mean ± SD)	p
Special Preparation Phase	10	23.30 ± 1.33	32.50 ± 1.64	p < 0.001
Conventional	12	19.91 ± 1.31	31.41 ± 2.46	p < 0.001

Note: Paired t-test used (p < 0.05)

Differences in Effects on Agility

To analyze the effect of the Special Preparation Phase Training on agility, a paired t-test (p < 0.05) was conducted because the data were normally distributed. The results of the paired t-test showed an increase in agility in karate athletes after undergoing Special Preparation Phase Training (26.50 ± 2.33 vs. 32.95 ± 5.52; p < 0.001). The complete analysis results are listed in Table 4.10.

To analyze the effect of Conventional Training on agility, a paired t-test (p < 0.05) was conducted because the data were normally distributed. The results of the paired t-test showed an increase in agility in karate athletes after receiving Conventional Training (28.10 ± 1.28 vs. 38.70 ± 1.15; p < 0.001). The complete analysis results are listed in Table 4.10.

Results of the analysis using an unpaired t-test (p < 0.05) revealed that agility in athletes who received Conventional Training was better compared to agility in athletes who received Special Preparation Phase Training (38.70 ± 1.15 vs. 32.95 ± 5.52; p < 0.001).

Table 10. The Effect of Specialized Preparation Training and Conventional Training on Agility in Karate Athletes (n=22)

Type of Training	n	Pre (Mean ± SD)	Post (Mean ± SD)	p
Special Preparation Phase	10	26.50 ± 2.13	32.95 ± 5.52	p < 0.001
Conventional	12	28.10 ± 1.28	38.70 ± 1.15	p < 0.001

Note: Paired t-test used (p < 0.05)

Discussion

Study on the Differences in the Effects of Specialized Preparation Training and Conventional Training on Lactate Levels and Basic Physical Abilities in Karate Athletes: Upper Body, Lower Body, and Back Strength; Abdominal, Shoulder, and Lower Body Endurance; Lower Body and Upper Body Explosive Power; Flexibility; and Agility.

The study found the following results: Specialized Preparation Training was more effective than Conventional Training in reducing lactate levels in karate athletes. Based on the results of the Mann-Whitney U test ($p < 0.05$), lactate levels in athletes who underwent Specialized Preparation Training were lower than those in athletes who underwent Conventional Training (53.10 ± 1.10 vs. 84.41 ± 2.27 mmol/L).26,49,53

This study found lower lactate levels after karate athletes underwent a specialized preparatory training program. The level of lactate in karate athletes depends on their anaerobic threshold. Lactate levels are lower in highly trained karate athletes because they have a greater capacity to eliminate lactate. Lactate elimination is primarily carried out by the liver and to a lesser extent by other body tissues, namely the kidneys and the heart. At rest, the kidneys and heart use lactate as an energy source, while the liver uses lactate as a raw material in gluconeogenesis. During karate training, there is an increase in lactate utilization by the heart muscle. The heart has the ability to eliminate lactate because heart muscle contains more lactate dehydrogenase enzyme compared to skeletal muscle.26,49,53

Lactic acid has long been considered a harmful metabolic byproduct, as it causes feelings of fatigue and muscle soreness in athletes. However, recent research has shifted this understanding, and it is now widely accepted that lactic acid serves as a readily available energy source when combined with oxygen. Lactic acid is produced by the reduction of pyruvic acid; this process occurs in muscle tissue that is oxygen-deprived, such as during training or competition for karate athletes.8,9,74

Researchers measured lactate levels before and after exercise. The results showed that the average blood lactate levels before and after exercise differed significantly (0.30 mmol/L vs. 0.883 mmol/L). Very little lactate is excreted through urine and the skin. Venous blood lactate levels at rest are 0.63–2.44 mmol/L or 5.7–22.0 mg/100 mL, while the largest source of lactate at rest comes from the breakdown of glucose within blood cells.8,9,74

The use of lactic acid as an energy source is closely linked to a decrease in lactic acid levels in the bloodstream. The balance of lactic acid levels in the bloodstream can hypothetically be explained through the glucose paradox and the lactic acid shuttle. Lactic acid production is highly dependent on the intensity of training or competition for karate athletes. In trained individuals, the elimination process is faster than in untrained individuals; this is the situation that explains regarding the group of karate athletes who participated in the Special Preparation Phase Training, who had lower lactate levels after the training program.8,9,74,107

A 2006 study on lactate by Dugué B, Grappe F, and Rouillon J., titled "Maximal Accumulated Oxygen Deficit and Blood Responses of Ammonia, Lactate, and pH after an Anaerobic Test: A Comparison between International and National Elite Karate Athletes." The results of the study showed that international karate athletes were better trained than national karate athletes, with lower lactate levels (13 vs. 17 mmol/L).25,49,54

This study also found that Specialized Preparation Training was more effective than Conventional Training in improving muscle function, as determined by an unpaired t-test ($p<0.05$), specifically: Lower Limb Muscle Strength (197.00 ± 12.44 vs 77.33 ± 1.66; $p < 0.01$), Abdominal Muscle Endurance (46.60 ± 2.22 vs. 33.75 ± 1.54, $p < 0.001$), Shoulder Muscle Endurance (49.20 ± 1.68 vs. 33.75 ± 2.76, $p < 0.001$), Lower Limb Muscle Endurance (48.90 ± 3.75 vs 29.00 ± 1.04, $p<0.001$), Lower Limb Muscle Power (54.10 ± 2.42 vs 39.25 ± 0.86), Upper Limb Muscle Power (39.80 ± 2.78 vs 34.16 ± 2.62, $p<0.001$).

Improvements in muscle function, including muscle strength, occur after completing a specialized preparatory training phase, as the training load utilizes weight training with a measured intensity. This training program enhances muscle function, specifically muscle strength, explosive power, and endurance. A measured and continuous training periodization program using weight training for 6–10 weeks can increase muscle strength at an appropriate intensity (8–12 RM), with 3 sets per exercise. This muscle strength training must be maintained with a training frequency of 2–3 times per week using weight training to ensure that the karate athlete's muscle strength remains in optimal condition.99,100,101

A consistent and structured training program, such as the training periodization program at TPK, will result in physiological and biochemical changes in the muscles. The physiological changes that occur alongside increased lower-body muscle strength include lower-body muscle hypertrophy. Weight training increases muscle cells' demand for oxygen and nutrients, leading to the growth of intracellular structures, including an increase in the number of mitochondria, endoplasmic reticulum, intracellular vesicles, and contractile proteins.99,100,101

Weight training at 15–25 RM will improve muscular endurance. Skeletal muscle endurance is the ability of skeletal muscles to perform repeated contractions or movements over an extended period of time. Muscle endurance can be trained using weight training at a frequency of 2–3 times per week, with 15–25 RM repetitions for 3 sets. Physiological adaptations to muscle endurance training typically develop after 6–12 weeks of training.8,9,12,30

Other physiological changes resulting from weight training at 12–15 RM during the Special Preparation Phase will enhance muscular explosiveness. Muscular explosiveness is more commonly referred to as explosive strength or muscular power—the ability to perform sudden, rapid movements by exerting maximum force in the shortest possible time.32,33,81

Muscle explosive power in karate athletes can be improved through plyometric training during the specific preparation phase, which involves dynamic resistance exercises— —utilizing body weight. Plyometric training is performed by jumping from a specific starting position, landing in a half-squat with both feet, then quickly jumping back up, and repeating this sequence repeatedly.4,9,32

Flexibility is a crucial and essential component in all sports, particularly for karate athletes. Flexibility supports the physical performance of karate athletes because it relates to joint range of motion, ensuring that their agility remains at an optimal level. Flexibility is also determined by the elasticity of muscles, tendons, and ligaments.24,33,73,102

Flexibility can be improved through stretching. Types of stretching include ballistic stretching, passive stretching exercises, and Proprioceptive Neuromuscular Facilitation (PNF) exercises. Research shows that PNF exercises are more effective than passive stretching for improving flexibility ($p<0.05$). PNF exercises to improve flexibility are performed 5 times a week for 15–30 minutes per day, in 3 sets, with each set lasting 20–30 seconds.9,31,79

Agility is the body's ability to move, change direction, and adjust body position quickly and precisely without losing balance or awareness. Experts emphasize that agility is the result of a complex combination of speed, flexibility, and explosive power, and is a physical component essential for karate athletes to excel.75,80,88,105

The technical dexterity of karate athletes is largely determined by their agility, and this agility is a multifactorial physical ability influenced by explosive power, speed, balance, muscle coordination, and flexibility.35,36,87,95

CONCLUSION

Based on the research findings, the following conclusions can be drawn:

1. Specialized Preparation Training Is More Effective Than Conventional Training for Reducing Lactate Levels in Karate Athletes.
2. Specialized Preparation Phase Training is more effective than Conventional Training for increasing lower-body muscle strength in karate athletes.
3. Specialized Preparation Phase Training is more effective than Conventional Training for improving abdominal muscle endurance in karate athletes.
4. Specialized Preparation Phase Training is more effective than Conventional Training for improving shoulder muscle endurance in karate athletes.
5. Specialized Preparation Phase Training is more effective than Conventional Training for improving leg muscle endurance in karate athletes.
6. Specialized Preparation Training is more effective than Conventional Training for improving lower-body explosive strength in karate athletes.
7. Specialized Preparation Phase Training is more effective than Conventional Training for improving the explosive strength of the upper body muscles in karate athletes.
8. Specialized Preparation Phase Training is more effective than Conventional Training for improving flexibility in karate athletes.

9. Conventional training is more effective than Specialized Preparation Phase training for improving the agility of karate athletes.

REFERENCES

Ainsworth BE, Haskell WL, and Leon AS. 2011;25:71–80. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc.

American College of Sports Medicine (ACSM). 2016. The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in Healthy Adults. Medicine & Science in Sport & Exercise.

Atkins SJ. 2004. Normalizing expressions of strength in elite rugby league players. J Strength Cond Res 18:53-58.

Bieze AJ, Gnacinski MR, Rouse AR, Sounberg SA. 2006. Effect of a chronic PNF stretching program on speed and explosiveness in Division III collegiate athletes. Journal of Undergraduate Kinesiology Research, vol. 2, no. 1, pp. 21–25.

Bloomfield J, Polman R, Donoghue P, and McNaughton L. 2007. Effective speed and agility conditioning methodology for random intermittent dynamic type sports. J Strength Cond Res.

Bompa TO, Haff GG. 2018. Periodization: Theory and Methodology of Training. Champaign, Illinois: Human Kinetics Publisher.

Boron WF. 2008. Medical Physiology: A Cellular and Molecular Approach. Elsevier/Saunders.

Chamari K, Paulo S, Paulo S. 2012. Physical and Physiological Profile of Elite Karate Athletes.;42(10):829–43.

Coutts AJ, Wallace LK, and Slattery KM. 2007. Monitoring changes in performance, physiology, and biochemistry during overreaching and recovery in triathletes. Int J Sports Med 28: 125–134.

Cronin JB and Hansen KT. 2005. Strength and power as predictors of sports speed. J Strength Cond Res.

Doria C, Veicsteinas æA, Limonta æE, Maggioni MA, Aschieri æP, Pietrangelo æT. 2009. Energetics of karate (kata and kumite techniques) in top-level athletes.;603–10.

Dugué B, Grappe F, Rouillon J. 2006. Maximal Accumulated Oxygen Deficit and Blood Responses of Ammonia, Lactate, and pH after an Anaerobic Test: A Comparison between International and National Elite Karate Athletes. 810–7.

Ezechieli M, Siebert CH, Ettinger M, Kieffer O, Weisskopf M, Miltner O. 2013. Muscle strength of the lumbar spine in different sports. Technol. Health Care. 21, 379–386.

Foss ML and Keteyian SJ. 2006. Physiological Basis for Exercise and Sport. McGraw-Hill Companies, New York. pp. 59–64.

Foss ML, Keteyian SJ. 2006. Physiological Basis for Exercise and Sport. McGraw-Hill Companies, New York. pp. 59–64.

Foss ML, Keteyian SJ. 2013. Fox's Physiological Basis for Exercise and Sport. New York: The McGraw-Hill Companies, Inc.

Franchini E, Chaabene H, Miarka B. 2015. Time-Motion Analysis and Physiological Responses to Karate Official Combat Sessions: Is There a Difference Between Winners and Defeated Karate Athletes.

Frank C. Mooren. 2007. Molecular Exercise Physiology. USA: Lippincott.

Gabbett TJ, Kelly JN, and Shepard JM. 2008. Speed, change of direction speed, and reactive agility of rugby league players. J Strength Cond Res.

Gabriel DA, Kamen G, and Frost G. 2006. Neural adaptations to resistive exercise: Mechanisms and recommendations for training practices. Sports Med 36:133–149.

Guyton AC & Hall JE. 2020. Textbook of Medical Physiology, 14th edition. Elsevier Saunders, Philadelphia, Pennsylvania.

Jensen and Fisher. 2000. Scientific Basis of Athletic Conditioning. Philadelphia: Lea Febinger.

Kerstin W, Siegfried K, Sabine D, et al. 2015. Comparing the effectiveness of karate and fitness training on cognitive functioning in older adults— A randomized controlled trial. Journal of Sports and Health Science 5. 484-490.

Lentz D and Hardyk A. 2005. Speed training. In: Training for Speed, Agility, and Quickness. LE Brown and VA Ferrigno, eds. Champaign, IL: Human Kinetics.

McArdle WD, Katch VI. 2010. Exercise Physiology: Energy, Nutrition, and Human

Performance. Baltimore: Williams and Wilkins.

McComas AJ, Gardiner PF. 2006. Skeletal Muscle form and function. Human Kinetics. USA. pp.215-220.

Menderes K, Soner K, Ali K Y, et al. 2022. Effects of Core Training on the Physical Fitness of Youth Karate Athletes: A Controlled Study Design. International Journal of Environment Research and Public Health.

Moir G, Sanders R, Button C, and Glaister M. 2007. The effect of periodized resistance training on accelerative sprint performance. Sports Biomechanics 6:285–300.

Morcelli MH, Oliveira JM, and Navega MT. 2013. Comparison of static, ballistic, and contract-relax stretching in the hamstring muscle. Fisioter. Pesqui. vol. 20, no. 3.

Morcelli MH, Oliveira JM, Navega MT. 2013. Comparison of static, ballistic, and contract-relax stretching in the hamstring muscle. Fisioter. Pesqui. vol. 20, no. 3.

Mori. 2002. Independent Game No No Kyofu. Sheikatsujin Shinso.

Moscatelli F, Valenzano A, Petito A, et al. 2016. Relationship between blood lactate and cortical excitability in taekwondo athletes and non-athletes after hand-grip exercise.

Nala. 2015. Principles of Sports Physical Training. Graduate Program in Sports Physiology, Udayana University, Bali.

Pangondian Hotliber. 2017. The Relationship Between Flexibility and Agility on the Speed of the Mawashi Gery Chudan Kick in Karate Athletes from the Wadokai Dojo UNIMED. Jurnal Prestasi Vol 1, No 1: 11-16.

Plisk SS. 2008. Speed, agility, and speed-endurance development. In: Essentials of Strength Training and Conditioning. TR Baechle and RW Earle, eds. Champaign, IL: Human Kinetics.

Pratama MN, Asnawati, Husairi A. 2020. Differences in reaction time between Sbrunners who jog regularly and irregularly. Homeostasis, Vol. 3 No. 1: 125–128.

Przybylski P, Janiak A, Szewczyk P, Wieliński D, Domaszewska K. 2021. Morphological and Motor Fitness Determinants of Shotokan Karate Performance. Int. J. Environ. Res. 18, 4423.

Purba A. 2016. Cardiovascular Physiology. Padjadjaran University: Department of Physiology/Exercise Physiology.

Quinn E. 2008. Energy Pathways for Exercise - How Carbohydrate, Fat, and Protein Fuel Exercise. Available from: http://sportsmedicine.about.com/cs/nutrition/a/aa080803a.htm

Ravier G, Dugué B, Grape F, Rouillon D. 2006. Maximal Accumulated Oxygen Deficit and Blood Responses of Ammonia, Lactate, and pH after an Anaerobic Test: A Comparison between International and National Elite Karate Athletes. 27:810–817.

Robert KM, Daryl KG, Victor WR. 2012. Harper's Biochemistry. 29th ed. Jakarta: EGC Medical Book Publisher.

Stone MH, Stone ME, and Sands WA. 2007. Principles and Practice of Resistance Training. Champaign, IL: Human Kinetics.

Sugiyono. 2014. Quantitative, Qualitative, and R&B Research Methods. Bandung: Alfabeta.

Wilmore JH and Costill David. 2008. Physiology of Sport and Exercise: 4th Edition. Champaign, IL: Human Kinetics.

Wilmore JH and Costill David. 2008. Physiology of Sport and Exercise: 4th Edition. Champaign, IL: Human Kinetics.