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The effect of four-week high-intensity interval training on increasing physical fitness and specific speed in young Pencak Silat athletes

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ABSTRACT

This study aimed to determine the effect of high-intensity interval training (HIIT) on increasing aerobic performance and speed, specifically for Pencak Silat athletes. Thirteen student-level Pencak Silat athletes were selected using consecutive sampling methods and then divided into two groups: the experimental group (EG, n = 7) and the control group (CG, n = 6). The HIIT protocol on EG consists of 2 minutes x 3 sets, with a 1-minute rest interval between sets to adapt to the motion demands during the match. Yo-Yo Intermittent Recovery Test Level 1 (YYIR1) was used to measure aerobic performance capacity (VO_2max) and FST to measure total kicks between pre- and post-HIIT. The results of the study showed that there was an increase in VO_2max on EG (44.86±1.90 vs. 48.42±2.67 mL/kg/min; p=0.000) and CG (42.43±1.85 vs. 44.02±2.18 mL/kg/min; p=0.020). The mean delta in VO2max increased between the two groups, with a significant difference ($p \leq 0.05$), and the EG produced a larger effect size compared to the CG. For total kicks, there was a substantial increase between pre-post on EG (105.72±7.89 vs. 112.57±8.91 n; p=0.001), while CG did not show any significant difference ($p \geq 0.05$). These findings prove that the Pencak Silat-specific HIIT protocol can improve aerobic performance and speed specifically for Pencak Silat athletes.

KEYWORDS

HIIT; Aerobic Performance; Special Speed Endurance; Pencak Silat Athletes

1. INTRODUCTION

Pencak Silat is a martial arts sport that was born as a culture of society, especially in the Southeast Asian region (Aziz et al., 2002). Along with the times, Pencak Silat is now more popular as an achievement sport that considers officially competing at various levels of championships, both nationally and internationally. One of the categories contested is the fighting category, where the implementation of the match displays a full-body contact fight between two fighters, involving attack-defense actions by prioritizing the rules and aspects of Pencak Silat (International Pencak Silat Federation, 2013). Like martial arts in general, Pencak Silat competitions are limited by specific rules set by the international martial arts organization, namely the International Pencak Silat Association (PERSILAT).

The Pencak Silat category of fighting consists of three rounds with a clean duration of two minutes each and interspersed with one minute of rest breaks between rounds. In each round, both fighters are required to produce value through mutually attacking actions with the rules and principles of Pencak Silat that have been set by the federation. Actions of high-intensity attack and defense that are carried out repeatedly involve special skills (technique-tactics) explosively and powerfully, thus requiring athletes to have good physiological attributes to support optimal performance in every battle (Aziz et al., 2002; Soo et al., 2018; Subekti et al., 2021). Each action of special techniques, such as hitting, kicking, and slamming is carried out in an explosive motion repeatedly during the active duration of the match (2 minutes x 3 rounds), thus indicating a high demand for anaerobic and aerobic metabolic responses (Ihsan et al., 2018; Soo et al., 2018). This causes a fighter to need high cardiorespiratory fitness, including dominant oxidative energy requirements through the ATP-PC pathway, and at peak fatigue conditions, the glycolytic system is sufficient to produce a fast recovery phase during competition (Bhagwat et al., 2021; Lubis et al., 2021).

Martial arts competitions are always associated with intermittent activity where there is high-intensity work in attack-defense actions, interspersed with low-intensity rest breaks, thus showing the involvement of two aerobic and anaerobic energy systems that influence each other (Vecchio et al., 2011; Franchini, 2020; Franchini et al., 2011; Silva & Franchini, 2021). During Pencak Silat fights, the dominant energy system comes from the oxidative system (77%), responsible for the recovery process between attack-defense efforts, followed by ATP–PC (phosphagen system, 19%), responsible for high-intensity scoring actions, and the glycolytic system by 4% (Sartono et al., 2018).

The importance of a Pencak Silat athlete having aerobic endurance is based on the demands of high-intensity technical-tactical actions which are carried out repeatedly for a duration of ≥ 2 minutes times 3 rounds of normal match time. Therefore, aerobic endurance has a vital role for Pencak Silat athletes in the combat category. This aims to prevent excessive fatigue in athletes and produce a good recovery process. One of the most important factors for achieving optimal performance in athletes is the level of aerobic endurance which can be seen by how much maximum oxygen volume capacity (VO_2max) is produced (Chaabene et al., 2017). To achieve good aerobic fitness status, an appropriate training method is needed, and by the demands of time movement activities during martial arts competitions, especially in improving performance in competitions (Lopes-Silva & Franchini, 2021).

Studies on martial arts in recent years have shown an increase in the interest of researchers in exploring the structure of combat sports in martial arts that try to link intermittent performance modalities (high intensity) and the need for aerobic fitness to maintain performance in competition (Marcon et al., 2011; Ouergui et al., 2014; Silva et al., 2011; Subekti et al., 2021; Tabben et al., 2015). Most of the research results show the relevance of fighting structure to the high-intensity interval training (HIIT) protocol which is recommended as an alternative exercise to improve athletes' physical performance (Sari-sarraf et al., 2020; Enrique et al., 2020; Herrera-Valenzuela et al., 2020; Franchini et al., 2019; Vecchio et al., 2011). HIIT training protocols can be designed keeping in mind the specifics of the sport as well as simulating a real match (Franchini, 2020; Valenzuela et al., 2021).

Previous studies have reported that drafting HIIT protocols in martial arts can take into account the demands of time movement and technical-tactical actions during the fighting period (Franchini et al., 2017; Monteiro et al., 2020). Identification of time movement produces data on the ratio of high-intensity work and rest intervals, which are used as the basis for determining the ratio (work:rest) in the HIIT protocol (Vecchio et al., 2011; Tabben et al., 2015), while the specific motor action shows the structure of the dominant technical-tactical action carried out in the game. As research by Ribeiro et al (2015) recommends a training program for Brazilian jiu-jitsu where specific 3-5 seconds of high-intensity efforts are interspersed with 20-25 seconds of low-intensity actions adhering to the HI:LI (1:6) ratio scheme. Another study by Vecchio et al (2011) for MMA athletes, the recommended ratio of effort:pause (2.4:1) and HI:LI (1:1.6) is determined based on an analysis of 245 rounds of 145 national matches and 13 matches at the World Wushu championships.

Fulfillment of optimal physical needs and technical abilities is a training target that must be achieved. The implementation of the program needs to be adjusted to the demands of movement and time activities during the competition period. So far, the preparation of training programs for the sport

of Pencak Silat has not done much to develop training models designed based on the demands of physical needs and the structure of motion during matches. Most coaches tend to rely on tradition, intuition, and experience. Strength and conditioning exercises that are applied are general and more often adopted training methods in sports that are similar to the characteristics of Pencak Silat. In addition, the training program undertaken by the athletes has not yet received a clear evaluation procedure, so the impact of the training results on the athlete's performance is unknown. The limited studies related to specific training programs for the sport of Pencak Silat are one of the bases for an earlier study of relevant training recipes developed to improve the performance of Pencak Silat athletes, especially in athletes in the combat category. Therefore, this study aims to determine the effect of high-intensity interval training on increasing aerobic performance and the specific speed of Pencak Silat. The results of this study can be used as a basis for practical recommendations in developing training programs to improve the performance of Pencak Silat athletes.

2. METHODS

2.1. Participants

This research was a experimental study involving 13 regionally trained individuals using consecutive sampling methods, with ≥ 3 years of experience competing in professional Pencak Silat sports competitions. All participants were used to the frequency of exercise 3x/week and all participants were confirmed not to be under medical treatment or have a history of sports injuries or other chronic illnesses as evidenced by the results of medical examinations carried out by a team of doctors provided by the research team. Before the intervention, the participants had understood the experimental procedures and risks related to the high-intensity interval training (HIIT) program specifically for the sport of Pencak Silat. All participants are required to sign a written informed consent from their parents and are willing to comply with the research procedures from the beginning to the end of the study. The selected Pencak Silat athletes were randomly divided into two groups, namely the control group (CG; n = 6), and experimental group (EG; n = 7). Participants in the control group carried out a regular training program 3x/week for 4 weeks, while participants in the experimental group carried out a regular training program and an additional special HIIT protocol program for Pencak Silat which was carried out with a frequency of 3x/week for 4 weeks.

2.2. Procedure

The participants were randomly divided into two groups, whereas the control group underwent regular Pencak Silat training sessions (90 minutes) with a frequency of 3x/week for 4 weeks.

Meanwhile, the experimental group underwent the same regular training sessions as the control group, and an additional HIIT program specifically designed for the sport of Pencak Silat (short duration and involving special skills of Pencak Silat). The details of the training programs of the two groups are as follows:

1. *Regular martial arts training:* CG participants participate in regular Pencak Silat training sessions for 4 weeks with a frequency of 3 times per week. The duration of 1 training session is 90 minutes, consisting of 15 minutes of warm-up, 60 minutes of core exercises, and 15 minutes of cooling down after practice. In the usual warm-up session using static and dynamic stretching followed by kicking and hitting the punch box (60-70% HR_{max}). The core training session consists of technical and tactical exercises (80-90 HR_{max}) aimed at preparing athletes to adapt to competitive conditions. This session was divided into 3 sets, each set lasting 20 minutes including a rest break. In the last session, the participants cooled down with paired flexibility exercises.
2. *High-intensity interval training (HIIT) protocol:* The special HIIT protocol was designed based on the movement structure of a Pencak Silat competition based on the results of previous studies which showed that the average duration of work time (HIA+LIA) was 11 seconds, while the average rest time was 11.3 seconds (Subekti et al., 2021). Because of this, a 1:1 ratio is obtained which is considered the highest work: rest (W:R) ratio in a Pencak Silat match. The Pencak Silat-specific HIIT protocol considers the temporal structure of the Pencak Silat competition in the sparring category which consists of 3 sets of 2 minutes each set and 1 minute rest interval between sets (International Pencak Silat Federation, 2013). Each participant in the experimental group carried out a series of motor actions (punches, kicks, and slams) beginning with a stance and step pattern 3 meters away from the target box/sack. The highest W:R (1:1) ratio is set, the motor action time is rounded off by 10 seconds, while the interval between actions is modified from 1:3 (10:30 seconds), 1:2 (10:20), and 1:1 (10:10) seconds, which was increased gradually over 4 weeks of treatment with a frequency of exercise 3 times per week. This HIIT protocol was given to the experimental group in regular training sessions (3rd set of core exercises) with a training intensity between 90% - 105% HR_{max}, increased gradually referring to the recommendations for short HIIT exercises for martial arts (Franchini et al., 2017). For more details, the specific HIIT program for Pencak Silat can be seen in Table 1 below.

Table 1. Description of the Pencak Silat Specific HIIT Program

Training Protocol (ratio= W:R)	Frequency per Week	Exercise Intensity % HR_{max})	Set	Rest between sets
Week I (1:3) 4 x 10 seconds of all-out effort (combined punches and kicks) with 30 seconds of passive rest intervals	3 times	85-95% HR_{max}	3	1 minute
Week II (1:2) 5 x 10 seconds of all-out effort (combined punches and kicks) with 20 seconds of passive rest intervals	3 times	95-100% HR_{max}	3	1 minute
Week III (1:2) 5 x 10 seconds of all-out effort (combined punches and kicks) with 20 seconds of passive rest intervals	3 times	95-100% HR_{max}	3	1 minute
Week IV (1:1) 6 x 10 seconds of all-out effort (combined punches and kicks) with 10 seconds of passive rest intervals	3 times	100-105% HR_{max}	3	1 minute

Note. W:R: Work:Rest; HR_{max}: maximal heart rate.

2.3. Performance assessment

1. *Aerobic performance assessment (VO_2max):* Measuring the athlete's ability to perform high-intensity aerobic performance using the Yo-Yo Intermittent Recovery Test Level 1 (YYIR1) test procedure to determine VO_2max capacity (mL/kg/min) and accumulated mileage applied to both the pre-exercise and post-exercise phases in the control group and the experimental group (Krustrup et al., 2003).
2. *Pencak Silat special performance assessment:* The special performance of Pencak Silat (total kicks) is assessed using the Frequency Speed Test (FST) adopting the Frequency Speed Kick Test (FSKT) procedure, which has been validated by previous studies (Silva & Franchini, 2016) in various martial arts athletes. The FST procedure consists of 5 reps of 10 seconds with 10-second rest intervals between sets. With the help of a sound signal, each participant performs as many sets of actions (kick) as possible on a punching bag (height 150 meters; diameter: 30 cm). The rating is determined based on the average number (kicks) of 5 sets. During FST the participant's heart rate is monitored using a Polar H10 heart rate monitor which is attached to the participant's chest and connected to the Polar Team mini application installed on the Apple iPad 9 with a capacity of 256 GB (Putera et al., 2023; Puspodari et al., 2022). Meanwhile, the

kick decrement index (KDI) during the test is calculated based on the formula adopted from previous studies and is presented below (Ojeda-Aravena et al., 2021).

$$\text{KDI}\ (\%) = \left[1 - \frac{\text{FSKT1} + \text{FSKT2} + \text{FSKT3} + \text{FSKT4} + \text{FSKT5}}{\text{Best FSKT} \times \text{Number of Sets}}\right] \times 100$$

2.4. Statistical analysis

Statistical analysis was performed with the help of SPSS 25 software with a significance level of 5%. Descriptive statistical data for each variable are presented in the form of mean and standard deviation (Mean ± SD). The distribution of data normality (prerequisite test) is proven by the Shapiro Wilk test. Hypothesis testing was done by paired sample t-test and independent sample t-test.

3. RESULTS

Based on the results of the analysis, there were no significant differences in the demographic data of research subjects between the control group (CG) and the experimental group (EG) ($p>0.05$) which can be seen in Table 2.

Table 2. Demographic data of research subjects

Parameters	Unit	CG (*n* = 6)	EG (*n* = 7)	*p*
		Mean ± SD	Mean ± SD	
Age	years	19.33±1.51	19.14±1.21	0.978
Weight	kg	65.20±7.94	58.17±4.66	0.231
Height	m	1.66±0.04	1.64±0.05	0.893
BMI	kg/m^2	23.66±1.51	21.63±1.33	0.652
Practice Time	years	4.88±1.15	4.98±0.98	0.974

Note. BMI: Body mass index; p-value was obtained by analyzing independent sample t-test.

Meanwhile, the results of the analysis of total kicks, maximum oxygen volume (VO_2max), accumulated distance, and the kick decrement index (KDI) between pre-exercise and post-exercise in each group are presented in Figure 1.

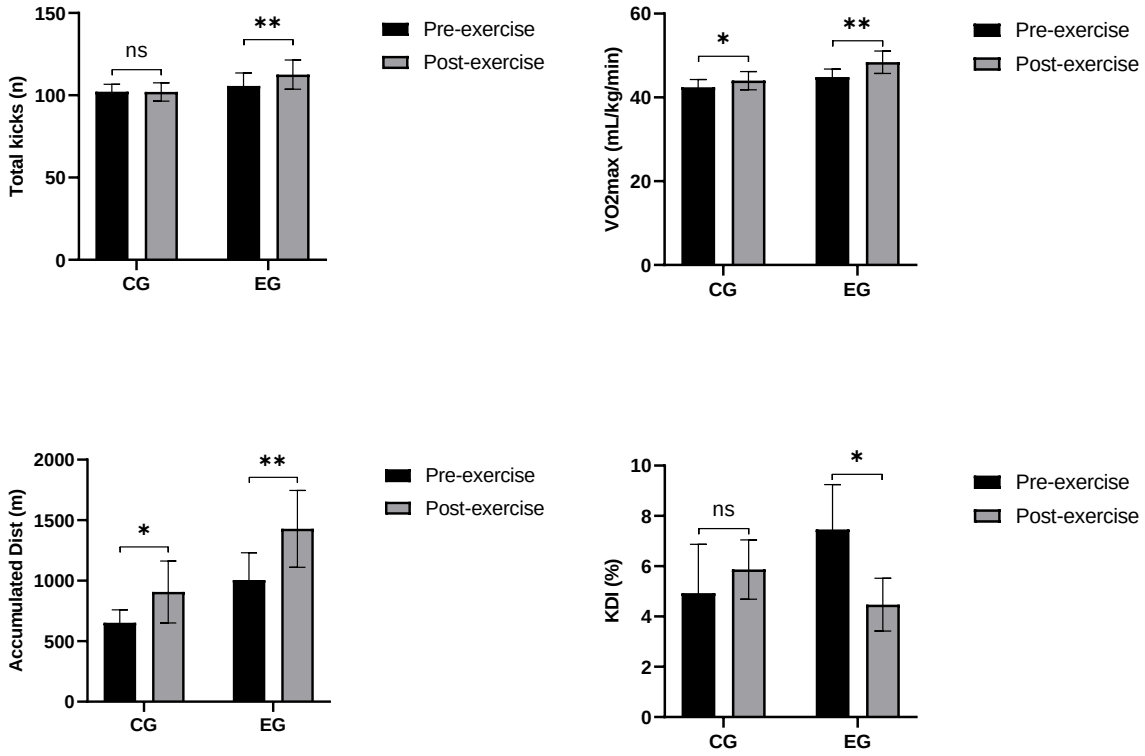

Figure 1. Average total kicks (n), VO_2max (mL/kg/min), accumulated distance (m), and KDI (%) between pre-exercise vs. post-exercise on CG and EG. *Note. (ns) Not significant; (*) Significant at pre ($p \leq 0.05$); (**) Significant at pre ($p \leq 0.001$); p-value was obtained by analyzing paired sample t-test.*

Table 3. Average total kicks, VO_2max, lengthier distance, and KDI between CG vs. EG at pre, post, and delta (Δ)

Observation point	Units	CG (*n* = 6)	EG (*n* = 7)	*p*
		Mean ± SD	Mean ± SD	
Pre-total kicks	n	102.17±4.54	105.72±7.89	0.336
Post-total kicks	n	102.0±5.55	112.57±8.91*	0.026
Δ-total kicks	n	-0.17±2.48	6.86±3.02**	0.001
Pre-VO_2max	mL/kg/min	42.43±1.85	44.86±1.90	0.071
Post-VO_2max	mL/kg/min	44.02±2.18	48.42±2.67*	0.007
Δ-VO_2max	mL/kg/min	1.58±0.93	3.56±1.09*	0.005
Pre-Accumulated distance	m	653.33±106.33	1005.72±225.59*	0.005
Post-Accumulated distance	m	906.67±256.33	1428.57±317.25*	0.007
Δ-Accumulated distance	m	253.33±185.33	422.86±130.35	0.094
Pre-KDI	%	4.93±1.95	7.46±1.79*	0.035
Post-KDI	%	5.87±1.18	4.47±1.05*	0.048
Δ-KDI	%	0.94±2.09	-2.99±2.28*	0.008

Note. (*) Significant at CG ($p \leq 0.05$); (**) Significant at CG ($p \leq 0.001$); p-value was obtained by analyzing independent sample t-test.

Table 3 presented the results of the analysis of total kicks, VO_2max, accumulated distance, and KDI between CG vs. EG at observation points, pre, post, and delta (Δ) , while Figure 2 presents the results of the analysis of changes in total kicks, VO_2max, accumulated distance, and KDI from pre-exercise between CG vs. EG

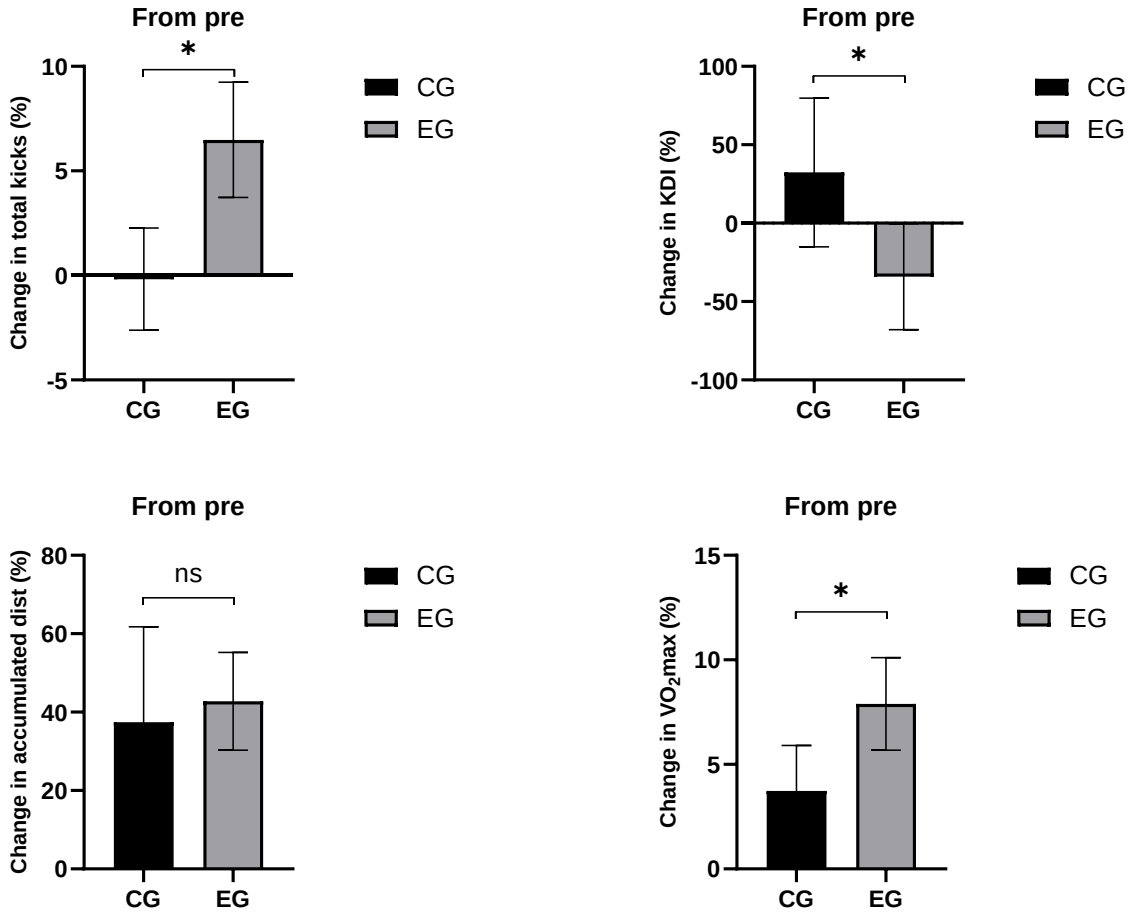

Figure 2. Changes in total kicks, VO_2max, accumulated distance, and KDI from pre-exercise between CG vs. EG. *Note. (ns) Not significant; (*) Significant at CG ($p \leq 0.05$); p-value was obtained by analyzing independent sample t-test.*

Table 4 presents the correlations between changes in VO_2max and changes in accumulated distance, total kicks, and KDI. A positive relationship ($p<0.05$) was found between aerobic performance (VO_2max) and total kicks, and accumulated distance, while aerobic performance (VO_2max) was found to have a negative relationship with KDI ($p<0.05$).

Table 4. The relationship between VO_2max and the accumulated distance, total kicks, and KDI

Parameters	Δ-VO_2max (mL/kg/min)	
	r	***p*-Value**
Δ-Accumulated distance (m)	0.798**	0.001
Δ-total kicks (n)	0.547*	0.043
Δ-KDI (%)	-0.581*	0.037

*Note. * Significant with p ≤ 0.05; ** Significant with p ≤ 0.001.*

4. DISCUSSION

The data analysis presented in Figures 1-2 and Table 3 shows an increase in aerobic performance (VO_2max), total kicks, accumulated distance, and a decrease in kick decrement index (KDI), where the experimental group (EG) gets a greater effect than the control group (CG). Meanwhile, this study also found a positive relationship between aerobic performance (VO_2max) and total kicks, and accumulated distance, while aerobic performance (VO_2max) was found to have a negative relationship with KDI (Table 4). This proves that the HIIT protocol based on the time structure of Pencak Silat has a better effect on VO_2max capacity, total kicks, accumulated distance, and decreased KDI. This finding is similar to the results of a previous study on boxing, where a short HIIT program with specific techniques increased VO_2max capacity (ES=+0.42 (small)) and number of strokes (ES=0.57 (medium)) during a simulated match (Herrera-Valenzuela et al., 2021). In line with the results of this study, Monteiro et al. (2020) has shown that the Wushu Sanda HIIT protocol (8 blocks of 15 seconds) applied to a small sample for 4 weeks can improve neuromuscular, aerobic, and anaerobic performance with large effect sizes.

As with martial arts in general, the characteristics of combat demand high aerobic performance capacity where an athlete must be able to perform repeated high-intensity counterattack actions and a fast recovery system. The HIIT protocol is recommended as an alternative training model that is relevant to all the demands of martial arts in supporting competition success (Yoshida et al., 2016). The specific HIIT program for Pencak Silat can increase aerobic performance, and the frequency of punches+kicks relevant to what is described by (Buchheit & Laursen, 2013) states that efficient HIIT characteristics in maximal utilization of the aerobic system up to greater than 100% will have an impact on passive recovery ability of up to 55%.

With regards to the sport-specific HIIT program for Pencak Silat, which recommends the design of the exercises following the movement structure during the match (2 minutes x 3 sets) interspersed with 1-minute rest between sets. The work:rest ratio is determined based on the time structure of the

fight (attack-defense) and the interval between fights (interval), which is between 1:3 to 1:1, with 10 seconds for high-intensity action. After 4 weeks of treatment with a frequency of 3 times/week, the HIIT protocol had a positive impact on increasing VO_2max capacity and punch+kick frequency. This effect is associated with an intensive HIIT program that can provide changes in aerobic and anaerobic performance, especially in martial arts athletes (Franchini et al., 2019).

Another interesting thing in this study is the choice of movements in this HIIT protocol using specific technical actions in the sport of Pencak Silat, thus providing the advantage of increasing the frequency of technical actions. This advantage is the effect of adaptation to the specific movements of certain sports, which leads to increased specific high speed, higher lactate tolerance, and fatigue levels resulting in better performance in implementing motor actions according to the demands of the competition (Ribeiro et al., 2015). One response from HIIT training is an increase in anaerobic performance metabolism, as a source of energy in high-intensity intermittent activities such as when performing special martial arts techniques, supported by high aerobic capacity in the recovery process (Bishop et al., 2011).

The results of this study can make a practical contribution to the development of science related to the effects of specific HIIT for Pencak Silat sports based on movement structures and match times, especially in efforts to improve aerobic performance and special speed in Pencak Silat. Of course, this can be used as a guide for coaches to apply in certain training sessions, especially during the special preparation phase up to pre-match. Furthermore, for academics, these findings can serve as a basis for future investigations emphasizing improving specific HIIT protocols that are closer to the demands of Pencak Silat fights which have a higher level of effectiveness than other training protocols.

5. LIMITATIONS

One of the limitations of this study is that the measurement of aerobic capacity has not used laboratory test procedures due to limited facilities. However, the application of YYIRTL1 has been validated by several previous researchers to have high data accuracy. In addition, the types of motor actions in the HIIT protocol have not been designed as closely as possible to the dominant technical demands in competition. An important finding of this study is that the Pencak Silat-specific HIIT protocol has a positive effect in increasing aerobic performance and the frequency of specific techniques so it can be recommended as a new training model for Pencak Silat trainers and practitioners by modifying high-intensity activities according to the training objectives.

6. CONCLUSIONS

These findings prove that the Pencak Silat-specific HIIT protocol can improve aerobic performance and speed specifically for Pencak Silat athletes. Therefore, the HIIT program can be an alternative training model for practitioners in an effort to improve the performance of Pencak Silat athletes. The HIIT protocol with a special design considering the time structure of Pencak Silat will result in an adaptation of the aerobic system that is useful for a quick recovery system during the match period. In addition, variations of the HIIT protocol with specific technical measures have a positive impact on the athlete's skill abilities. In particular, these results can be used as a basis for further research, with a research methodology approach that emphasizes the development of a specific HIIT design for Pencak Silat taking into account the various demands of motion, time and work, and rest ratios during the match period to optimize physical fitness and develop skills in the specialization of Pencak Silat.

7. REFERENCES

1. Aziz, A. R., Tan, B., & Teh, K. C. (2002). Physiological responses during matches and profile of elite pencak silat exponents. *Journal of Sports Science and Medicine, 1*(4), 147–155.
2. Bhagwat, A., Patole, S., & Golhar, S. (2021). The effectiveness of 5 weeks of high intensity interval training on cardiovascular endurance in karate players: An experimental study. *International Journal of Applied Research*, *7*(7), 318–323.
3. Bishop, D., Girard, O., & Mendez-Villanueva, A. (2011). Repeated-sprint ability - part II: recommendations for training. *Sports Medicine, 41*(9), 741–756. https://doi.org/10.2165/11590560-000000000-00000
4. Buchheit, M., & Laursen, P. B. (2013). High-intensity interval training, solutions to the programming puzzle: Part II: Anaerobic energy, neuromuscular load and practical applications. *Sports Medicine, 43*(10), 927–954. https://doi.org/10.1007/s40279-013-0066-5
5. Chaabene, H., Hachana, Y., Franchini, E., Mkaouer, B., & Chamiri, K. (2017). Physical and physiological profile of Iranian world-class karate athletes. *Biomedical Human Kinetics, 9*(1), 115–123. https://doi.org/10.1515/bhk-2017-0017
6. da Silva Santos, J. F., & Franchini, E. (2016). Is frequency speed of kick test responsive to training? A study with taekwondo athletes. *Sport Sciences for Health, 12*(3), 377–382. https://doi.org/10.1007/s11332-016-0300-2
7. del Vecchio, F. B., Hirata, S. M., & Franchini, E. (2011). A review of time-motion analysis and combat development in mixed martial arts matches at regional level tournaments. *Perceptual and Motor Skills*, *112*(2), 639–648. https://doi.org/10.2466/05.25.PMS.112.2.639-648
8. Enrique, D., Tapia, A., Barrera, V. R., Ferreira, J., Santos, S., Franchini, E., Valdés-Badilla, P., Orihuela, P., & Herrera-Valenzuela, T. (2020). High-intensity interval training improves specific performance in taekwondo athletes. *Revista de Artes Marciales Asiáticas, 15*(1), 4–13. https://doi.org/10.18002/rama

9. Franchini E. (2020). High-Intensity Interval Training Prescription for Combat-Sport Athletes. *International Journal of Sports Physiology and Performance, 15*(6), 767–776. https://doi.org/10.1123/ijspp.2020-0289
10. Franchini, E., Cormack, S., & Takito, Monica, Y. (2019). Effects of High-Intensity Interval Training on Olympic Combat Sports Athletes' Performance and Physiological Adaptation: A Systematic Review. *Journal of Strength and Conditioning Research, 33*(1), 242–252. https://doi.org/10.1519/JSC.0000000000002957
11. Franchini, E., del Vecchio, F. B., Matsushigue, K. A., & Artioli, G. G. (2011). Physiological profiles of elite judo athletes. *Sports Medicine, 41*(2), 147–166. https://doi.org/10.2165/11538580-000000000-00000
12. Franchini, E., Julio, U., Panissa, V., Lira, F., Agostinho., & Branco, B. (2017). Short-term low-volume high-intensity intermittent training improves judo-specific performance. *Journal of Science and Medicine in Sport, 20,* 219-229.
13. Herrera-Valenzuela, T., Carter, J., Leiva, E., Valdés-Badilla, P., Ojeda-Aravena, A., & Franchini, E. (2021). Effect of a short hiit program with specific techniques on physical condition and activity during simulated combat in national-level boxers. *Sustainability, 13*(16), 1-11. https://doi.org/10.3390/su13168746
14. Herrera-Valenzuela, T., Valdés-Badilla, P., & Franchini, E. (2020). High-intensity interval training recommendations for combat sports athletes during the COVID-19 pandemic. *Revista de Artes Marciales Asiáticas, 15*(1), 1-3. https://doi.org/10.18002/rama.v15i1.6230
15. Ihsan, N., Yulkifli, Y., & Yohandri, Y. (2018). Technology Based Instrument of Pencak Silat Speed Kick. *Journal of Sociotechnology. 17*(1), 124-131. https://doi.org/10.5614/sostek.itbj.2018.17.1.12
16. International Pencak Silat Federation. (2013). Competition Regulations (1st ed.).
17. 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 and Science in Sports and Exercise, 35*(4), 697–705. https://doi.org/10.1249/01.MSS.0000058441.94520.32
18. Lopes-Silva, J. P., & Franchini, E. (2021). Developing anaerobic power and capacity for combat sports athletes. *Revista de Artes Marciales Asiáticas, 16*(1), 60–85. https://doi.org/10.18002/rama.v16i1s.7001
19. Lubis, J., Fitrianto, E. J., Sukiri, Haqiyah, A., Setiakarnawijaya, Y., Robianto, A., Sukriadi, S., Nurulfa, R., Irawan, A. A., & Sumartiningsih, S. (2021). Does aerobic interval training induce a decrease in body weight in pencak silat elite athletes? *Journal of Physical Education and Sport, 21,* 2372–2380. https://doi.org/10.7752/jpes.2021.s4318
20. Marcon, G., Franchini, E., Jardim, J. R., & Barros Neto, T. L. (2011). Structural Analysis of Action and Time in Sports: Judo. *Journal of Quantitative Analysis in Sports, 6*(4), 1-19. https://doi.org/10.2202/1559-0410.1226
21. Monteiro, J. R. F., Vecchio, F. B. del, Vasconcelos, B. B., & Coswig, V. S. (2020). Specific wushu sanda high-intensity interval training protocol improved physical fitness of amateur athletes': A pilot study. *Revista de Artes Marciales Asiáticas, 14*(2), 47–55. https://doi.org/10.18002/rama.v14i2.6029

22. Ouergui, I., Hssin, N., Haddad, M., Franchini, E., Behm, D. G., Wong, delP., Gmada, N., & Bouhlel, E. (2014). Time-motion analysis of elite male kickboxing competition. *Journal of Strength and Conditioning Research, 28*(12), 3537–3543. https://doi.org/10.1519/JSC.0000000000000579
23. Puspodari, P., Wiriawan, O., Setijono, H., Arfanda, P. E., Himawanto, W., Koestanto, S. H., Hantoro, B., Lusianti, S., Putra, R. P., Prasetiyo, R., & Pranoto, A. (2022). Effectiveness of Zumba Exercise on Maximum Oxygen Volume, Agility, and Muscle Power in Female Students. *Physical Education Theory and Methodology*, *22*(4), 478–484. https://doi.org/10.17309/tmfv.2022.4.04
24. Putera, S. H. P., Setijono, H., Wiriawan, O., Nurhasan, Muhammad, H. N., Hariyanto, A., Sholikhah, A. M., & Pranoto, A. (2023). Positive Effects of Plyometric Training on Increasing Speed, Strength and Limb Muscles Power in Adolescent Males. *Physical Education Theory and Methodology*, *23*(1), 42–48. https://doi.org/10.17309/tmfv.2023.1.06
25. Ribeiro, R., Oliveira Silva, J. Í., Dantas, M. G. B., Menezes, E. S., Pereira Arruda, A. C., & Schwingel, P. A. (2015). High-intensity interval training applied in Brazilian Jiu-jitsu is more effective to improve athletic performance and body composition. *Journal of Combat Sports and Martial Arts*, *6*(1), 1–5. https://doi.org/10.5604/20815735.1166073
26. Sari-sarraf, V., Parnian-khajehdizaj, N. & Amirsasan, R. (2020). High-Intensity Interval Training and Continuous Training with Intermittent Calorie Restriction in Overweight Women: Effect on the Inflammation and Lipid Profile. *Spor Bilimleri Araştırmaları Dergisi, 5*(2), 230-246 . https://doi.org/10.25307/jssr.819590
27. Sartono, N., Puspitaningrum, R., Lubis, J., & Siregar, N. M. (2018). Profile energy national athlete of Indonesia Pencak silat. AIP Conference Proceedings, 2019 (October 2018), 1–5. https://doi.org/10.1063/1.5061901
28. Silva, J. J. R., Del Vecchio, F. B., Picanço, L. M., Takito, M. Y., & Franchini, E. (2011). Time-Motion analysis in Muay-Thai and Kick-Boxing amateur matches. *Journal of Human Sport and Exercise*, *6*(3), 490–496. https://doi.org/10.4100/jhse.2011.63.02
29. Soo, J., Woods, C. T., Arjunan, S. P., Aziz, A. R., & Ihsan, M. (2018). Identifying the performance characteristics explanatory of fight outcome in elite Pencak Silat matches. *International Journal of Performance Analysis in Sport*, *18*(6), 973–985. https://doi.org/10.1080/24748668.2018.1539381
30. Subekti, N., Syaifullah, R., Fatoni, M., & Syaukani, A. A. (2021). Pencak silat combat match: Time motion analysis in elite athletes championship. Spring Conferences of Sports Science. Costa Blanca Sports Science Events, 21-22 June 2021. Alicante, Spain.
31. Tabben, M., Coquart, J., Chaabène, H., Franchini, E., Ghoul, N., & Tourny, C. (2015). Time-motion, tactical and technical analysis in top-level karatekas according to gender, match outcome and weight categories. *Journal of Sports Sciences, 33*(8), 841–849. https://doi.org/10.1080/02640414.2014.96519
32. Yoshida, H. M., & dos Santos Neto, S. R. (2017). Wushu and Trainning Aspects: A Literature Review. *Caderno De Educação Física E Esporte, 14*(1), 69–78.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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