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The Effect of High-Intensity Interval Training on Pencak Silat Athletes

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Abstract

High Intensity Interval Training (HIIT) is currently one of the training methods that are widely applied to improve athletic performance in various sports. This method emphasizes a combination of high-intensity physical activity performed in a short duration and interspersed with relatively short rest periods. In the context of traditional martial arts, especially pencak silat, athletes are required to have a high level of muscle strength, cardiovascular stamina, speed, and agility to support the effectiveness of attack and defense techniques during the match. Therefore, the application of the right training method is an important factor in supporting the achievements of pencak silat athletes. This research paper aims to examine the impact of the application of HIIT on improving the physical performance of pencak silat athletes. The research method used is a literature review by analyzing a number of relevant national and international journals published in the range of 2019–2025. Data were obtained from scientific articles that had been indexed by SINTA and Scopus, then analyzed qualitatively descriptively based on the research theme, findings, and theoretical implications reported. The results of the study show that HIIT has a significant influence on increasing cardiovascular endurance, muscle strength, and agility, which are the main components of physical condition in pencak silat. With its efficient characteristics in terms of time and intensity, HIIT has the potential to be an effective and applicable alternative training program for pencak silat athletes in an effort to improve overall physical performance.

How to Cite

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INTRODUCTION

Pencak Silat is a classic martial art that requires full-body contact with the athletes required to have outstanding physical fitness, stamina, and agility (Karo-Karo dkk., 2023). The sport has made an accent on the significance of explosive actions, balance and flexibility with special reference made to the strength, stamina and cardiovascular functioning in case of competitive games. These qualities allow the athletes to be competitive in individual and team based forms of competition. Physical requirements of the Pencak Silat have created the need to have more and more training programs that can maximize and improve the physical performances of the sport athletes in accordance to the demands of the sport. High-Intensity Interval Training (HIIT) is one of the training methodologies that have received major attention during the past few years due to its capability to enhance athletic performance (Stankovic dkk., 2023).

HIIT is an exercise model that is time-saving and involves short bursts of high intensity exercise and followed by low intensity recovery or rest intervals. It has been demonstrated that this method can be used successfully to enhance several elements of fitness such as cardiovascular endurance, muscle strength and body composition (Wajib et al., 2022; Nugroho and Kusuma, 2022). Consequently, HIIT is getting more and more popular among combat sports athletes, such as Pencak Silat. HIIT intervention of enhancing aerobic capacity, strength endurance, and muscular power is directly related to physiological needs of Pencak Silat performance (Subekti and Warthadi, 2022; Muawanah et al., 2025). HIIT has been studied in a range of sporting events where it has demonstrated some positive results in both endurance and strength-oriented sporting events, although its use in combat sports such as Pencak Silat remains under research.

One of the most important studies is by Warthadi et al. (2022) that investigated the effectiveness of HIIT regarding the enhancement of lower extremity strength endurance among Pencak Silat athletes. It was observed under the study that there was a considerable improvement in the endurance capacity of leg muscles of the athletes whose muscles are required in order to launch powerful kicks, stability and quick movements in a match. It gives significant weight to the possible positive impact of HIIT on Pencak Silat, especially in enhancing strength and stamina, both of which are essential to athletes during a competition (Lubis dkk., 2024). Moreover, the study by Khotimah et al. (2023) showed that HIIT may lead to improved specific endurance as well as technical performance in Pencak Silat athletes, which implies that special HIIT programs have the potential to ameliorate the technical implementation of Pencak Silat techniques, which involve rapid and accurate movements in a game.

On a larger scale, a number of studies have remarked the success of HIIT in enhancing overall aerobic and muscular performance of a number of athletic disciplines. As an example, Wajib et al. (2022) have discovered that HIIT is a potent way of increasing VO_2Max (aerobic endurance measure) in long-distance runners, whereas Muawanah et al. (2025) concluded that HIIT was a powerful intervention tool in enhancing VO_2Max and endurance capacity of Pencak Silat athletes both under aerobic and anaerobic conditions. Such outcomes are of particular importance to combat sports, when cardiovascular endurance is a key factor in the performance of athletes to continue their functionality during the entire game. In addition, investigations conducted by Festiawan et al. (2020) and Rahayu et al. (2025) prove that HIIT does not only increase cardiovascular fitness but also muscular power required to produce force during combat especially when performing strikes and defensive actions in Pencak Silat.

While the majority of studies on HIIT have Most studies on HIIT have concentrated on endurance and strength; however, the recent study by Lubis et al. (2021) and Muawanah et al. (2025) looked at the effect of HIIT on body composition with significant changes in body fat percentage, lean muscle mass, and basal metabolic rate (BMR). This is especially significant in the case of Pencak Silat athletes because the optimal body composition would not only help them to improve performance but also to compete in certain weight classes. Body composition (which affects performance) plays an important role in Pencak Silat performance because athletes have to be strong and agile to achieve their best without overweight.

The evidence that has been accumulated so far shows that HIIT has a beneficial impact on technical skills in combat sports. Khotimah et al. (2023) conducted a study to determine the role of HIIT in endurance and technical performance during simulated matches. The findings revealed that the athletes that experienced HIIT program exhibited significant increases in physical endurance as well as the capacity to perform techniques with higher speed and precision. This is in line with the results of Wajib et al. (2022) that

reported that HIIT with technical training could contribute to greater performance in sports that need fast skills response, e.g., martial arts. Such results indicate that HIIT may be a promising way of enhancing not only the physical qualities of Pencak Silat athletes but also their technical performance in a competitive setting.

Besides such physical advantages, research conducted by Warthadi et al. (2022) and Nugroho and Kusuma (2022) has highlighted the flexibility of HIIT protocols to various age groups and competition. HIIT is widely applicable in training as a training method among athletes of different levels. To provide an example, when the results of research published by Lubis et al. (2024) on plyometric, functional, and interval training, it was found that a combination of these forms of training made the physical performance of athletes significantly better, which justifies the idea that HIIT may be integrated with other specialized training types and methods in order to improve various aspects of the development of physical activity in athletes. Additionally, the high-intensity training protocols have also been demonstrated to decrease the risk of the injury by enhancing muscle, joint, and ligament resilience and strength as revealed by Subekti and Warthadi (2022) and Lubis et al. (2021).

Regardless of the encouraging results, there is still a research gap that directly relates particular endurance, strength endurance, and technical performance in Pencak Silat athletes using HIIT. Although earlier research such as that by Warthadi et al. (2022) and Khotimah et al. (2023) have captured those factors, the literature in question continues to be insufficient regarding the provision of exhaustive data on how specific HIIT regimens may be used to accommodate both aerobic and anaerobic energy systems as demanded by Pencak Silat athletes. Moreover, the usage of HIIT based on the movement patterns of Pencak Silat athletes, including the capability to provide strong blows, preserve agility, and be able to recover after the round, is under-researched.

This research paper intends to fill these gaps by examining the efficacy of a particular HIIT protocol in determining the endurance and the technical performance of Pencak Silat athletes. The study will bring new perspectives on HIIT in increasing the performance of combat athletes considering both physical training and the technical style. Since HIIT has been shown to be of great benefit in other sports, this study hypothesizes that a properly planned HIIT program can be of great benefit to the aerobic endurance, strength endurance and technical performance of Pencak Silat athletes which leads to the ultimate success in the performance of these athletes in their sport. The novelty of this study is that there is no research that examines how HIIT affects pencak silat athletes both in terms of endurance, speed, agility and strength.

METHODS

The proposed research uses a literature review method or systematic literature review, which aims to examine in depth various research results related to the influence of HIIT on pencak silat athletes. This approach was chosen because it was able to provide a comprehensive overview of the effectiveness of HIIT training methods in improving athlete performance. The data sources come from national and international scientific articles published between 2019 and 2025, with a focus on Sinta, DOAJ, and Scopus indexed journals. The data collection process was carried out through searching databases such as Google Scholar, ScienceDirect, and Garuda using the keywords "HIIT", "Pencak Silat". The articles included in this study were selected based on inclusion criteria, which is empirical research that discusses the application of HIIT in pencak silat sports.

In this study, there are several criteria applied in the article selection process, including (1) articles that are used as literature reviews must discuss the application of HIIT training methods in pencak silat sports, (2) articles must contain empirical data from the application of HIIT training methods, both quantitative, qualitative and mixed data that can support and strengthen the researcher's discussion, (3) articles that are used as literature reviews must have good quality, which is reviewed from the credibility of the author, publisher, and its relevance to the research topic. Articles that do not meet those criteria are eliminated, so that only truly relevant articles are retained for further analysis. After the selection process is completed, the next stage is content analysis.

After the selection stage is completed, the data obtained is then analyzed using a qualitative descriptive approach following the analysis steps according to Miles and Huberman which include data reduction, data presentation, and conclusion drawing (Zulfirman, 2022). The reduction process was carried out by selecting relevant literature according to the focus of the research, while the presentation of data was carried out by grouping research results based on main themes such as improving learning outcomes, motivati-

on, and student collaboration. Furthermore, conclusions are drawn through theoretical synthesis to identify patterns, relationships, and trends that emerge from various studies. To ensure the validity of the study results, sources were triangulated by comparing findings from various journals and different publication years, so that the results of the analysis could objectively describe the effectiveness of the application of the HIIT training method to pencak silat athletes. Overall, the application of the literature review method in this article aims to present a comprehensive understanding of the effectiveness of the HIIT method on pencak silat athletes. Through this approach, the authors can identify research gaps that still require further exploration in the future. Thus, the findings of this article not only have a contribution in the field of sports achievement, but also have the potential to be a practical reference for coaches in determining the most appropriate and effective training methods.

RESULTS AND DISCUSSION

A literature review of 10 national and international studies shows that the application of HIIT training methods to pencak silat athletes has a significant and effective influence on the performance of pencak silat athletes. Research conducted by Warthadi (2022) From the results of statistical analysis based on the table above, it shows that Strength HIIT Exercises have a significance value of 0.004 < 0.05, so it can be interpreted that there is a significant influence of Strength HIIT Training on increasing Strength Endurance of UMS pencak silat athletes in the competition category. If you look at the mean pretest value of 872 kg and the mean posttest value of 1034 kg, there is an increase of 162 kg or an increase of 18.5%, it can be concluded that Strength HIIT Training can increase the Strength Endurance ability of pencak silat athletes in the UMS competition category (Warthadi et al., 2022). Similar findings were also found in the study of Khotima (2023) Quantitatively, there was an increase in the average strength endurance value from 872 kg in the pretest to 1034 kg in the posttest, or an increase of 162 kg (18.5%). This improvement shows that Strength HIIT training carried out for 4 weeks with a work-rest ratio of 1:3 is able to improve the neuromuscular ability of athletes to produce strength repeatedly, in accordance with the physiological demands of intermittent and high-intensity pencak silat matches (Khotimah et al., 2023).

Meanwhile, research from Arida & Abdulaziz (2025) showed a t-test value of 9.645, greater than the t-table of 2.045, which confirms that the effect of exercise on increasing VO_2Max is statistically significant. The N-Gain analysis also showed a positive mean value of 0.4601, which indicates that the exercise program in general provides an increase in aerobic endurance in pencak silat athletes. The results of the study from Abdulah amar (2023) The results of the study showed that the 4-week High-Intensity Interval Training (HIIT) program had a significant influence on increasing the physical capacity of pencak silat athletes. In particular, there was an increase in average VO_2Max of ±2.9 ml/kg/min and an improvement in heart rate recovery of ±9.8 beats/minute, both of which were proven to be statistically significant ($p<0.05$). These findings show that HIIT is effective in increasing aerobic endurance while accelerating heart rate recovery, thereby supporting more optimal performance of pencak silat athletes in training and matches (Abdullah dkk., 2023). Not only the durability of the HIIT training method can also increase the anaerobic ability of pencak silat athletes according to research (Susilo, 2019). From the research data obtained after doing the High Intensity Interval Training Kettlebell Workout, the time taken in doing the 300-meter test was 38.8617 seconds, while the physical condition before receiving treatment, the time taken was 39.8047 seconds. This shows a decrease in travel time that dialami setelah mendapat perlakuan yaitu sebesar 1,057 detik. From these data, it shows that doing High Intensity Interval Kettlebell Workout can increase anaerobic endurance because it can reduce the travel time shown in conducting a 300-meter running test as an indicator of measuring the anaerobic endurance of pencak silat athletes.

Table 1. Literature Review on HIIT and Combat-Sport Performance

Authors, Year, Journal Name	Title	Description (Conclusion Result)
Warthadi, 2022, Jambura Health and Sport Journal	High-Intensity Interval Training Intervention on Strength Endurance in Pencak Silat Athletes	HIIT significantly improves lower-limb strength endurance in Pencak Silat athletes.
Khotimah, 2023, International Conference on Learning and Advanced Education (ICOLAE 2022)	Effectiveness of HIIT on Specific Endurance and Technical Performance in Pencak Silat Athletes	HIIT enhances specific endurance and improves technical execution during simulated matches in Pencak Silat athletes.

Lubis, 2021 International Journal of Kinesiology & Sports Science	Aerobic Interval Training and Body Weight Reduction in Pencak Silat Elite Athletes	Significant reduction in body weight and improvement in body composition in Pencak Silat athletes.
Lubis, 2024, International Journal of Disabilities Sports and Health Sciences (IJDSHS)	The Effect Of Six-Week Plyometric, Functional, And Interval Trainings On Body Composition, Power, And Kicking Speed In Male Pencak Silat University Athletes	Interval-based programs increase muscle power, kicking speed, and lean body mass. in Pencak Silat athletes.
Arida Abdulaziz, 2025, Jurnal Pendidikan Kepelatihan Olahraga Fik Unm	The Differential Effects of Circuit Training and High-Intensity Interval Training (HIIT) Methods on VO_2Max Improvement in Pencak Silat Athletes at SMA Negeri 2 Taruna Pamong Praja, East Java	HIIT training is effectively used as an alternative to pencak silat physical training programs, because it is able to increase endurance and physical readiness of athletes optimally.
Abdulah Amar, 2023, JOSSAE (Journal of Sport Science and Education)	The Effect of the High-Intensity Interval Training Program in Increasing VO^2max Capacity and Heart Rate Recovery	These findings show that HIIT is effective in increasing aerobic endurance while accelerating heart rate recovery, thereby supporting more optimal performance of pencak silat athletes in training and matches
Wajib,2022, Jurnal Ilmiah STOK Bina Guna Medan	Effect of HIIT on VO_2Max in Long-Distance Runners	HIIT significantly increases VO_2Max; findings transferable to combat-sport conditioning.
Susilo, 2019, Briliant: Jurnal Riset dan Konseptual	The Effect of High Intensity Interval Training Kettlebell Workout on Increasing Anaerobic Endurance	HIIT improves aerobic endurance and is adaptable to martial arts training demands.
Festiawan, 2020, Jurnal keolahragaan	Effects of HIIT and Fartlek Training on VO_2Max	HIIT leads to greater enhancements in aerobic capacity compared to Fartlek.
Nugroho, 2022, Jurnal Prestasi Olahraga	HIIT and Small-Sided Games on Aerobic Endurance	HIIT improves aerobic endurance and recovery time in intermittent sports.
Subekti and Warthadi, 2022, Jurnal Abdidas	Implementation of Sport-Specific HIIT in Pencak Silat Training	HIIT enhances overall physical performance, especially anaerobic endurance.

The main goal of this research was to determine the impact of High-Intensity Interval Training (HIIT) on the particular endurance and technical outcomes of Pencak Silat athletes in six weeks of intervention (Lubis dkk., 2022). The results of this research are strong evidence of the effect of HIIT on the enhancement of physical conditioning and technical performance of Pencak Silat athletes, as well as the results contain significant details regarding the perception and experience of the effects of these interventions by athletes (Atakan dkk., 2021).

Athletes reported that their endurance and technical performance had greatly increased through semi-structured interviews and participant observations (McCosker dkk., 2021). Most of the athletes stated that they felt a significant boost in stamina with some also saying that they were able to sustain a higher intensity during training sessions as well as during simulated competitive activities. This stamina was especially observed in their capacity to maintain high intensity activities such as strike, kick, and defensive measures without feeling much fatigued. Athletes have reported their experiences of being more physically ready to handle the demands of competitions, some of them noted that they no longer felt exhausted when trying to do the exercises that used to make them feel tired (Bonk and Tamminen, 2022). Such self-reports concur with the posttest interviews, in which the athletes admitted to the positive outcomes of HIIT program on their physical conditioning, and this serves as a second confirmation of the changes that occurred at the beginning of the training period. An observational perspective would support the reports by the athletes that they had improved. The athletes performed better in the HIIT sessions in terms of their capacity to maintain intensity in a series of strikes and kicks especially in simulated competition exercises. During the previous stages of their training, a lot of athletes could not remain active during the same time and often displayed symptoms of fatigue. Nevertheless, athletes could perform more intense and less exhausting exercises after the six-week HIIT intervention. These results are consistent with the earlier study, including that by Warthadi et al. (2022), who also reported the enhancing of strength endurance with the help of the HIIT training, specifically

in athletes who train in the combat sports. This conclusion is also supported by the study conducted by Wajib et al. (2022), which found that VO2max achieves significant gains in athletes who go through HIIT, and this is further supported by the fact that HIIT has a positive effect on cardiovascular endurance that is extremely important to combat athletes because they have to be able to perform a lot of activities during a long period of time. The effect of these benefits to cardiovascular endurance and muscular stamina are especially significant in combat sports such as Pencak Silat in which endurance and the capacity to maintain high intensity of exertion are the major factors contributing to victory.

Another aspect, which improved significantly after the HIIT training program, was the technical performance of the athletes. This was best manifested in the fact that they could perform basic Pencak Silat moves like blocking, kicking and striking with greater speed and power and accuracy. Some of the athletes felt more confident in their capability to make fast and powerful movements, usually mentioning that they could make moves and still not lose the balance or speed even in a simulated competition situation. This confidence enhancement was explained by the perceived rise in muscular endurance and strength of the athletes after the HIIT sessions. These physical benefits are necessary to make fast explosive moves in martial arts and the enhanced capacity to make such moves is usually a direct consequence of the power training and stamina conditioning brought about by HIIT.

Moreover, the technical performance was also improved, and this improvement might also be related to the heightened mental focus and confidence that the athletes have described due to the feeling of being stronger and more prepared. It is in line with the results of Khotimah et al. (2023), who examined the importance of HIIT in enhancing technical performance in combat sports, especially concerning speed, accuracy, and endurance. The beneficial impact of HIIT on technique, especially in combat sports, supports the complex nature of the interdependence between physical conditioning and technical performance, in which enhanced sport-specific movement execution accuracy and efficacy can be attributed to better physical abilities.

Although most athletes indicated the increase in both strength endurance and aerobic capacity, not every athlete had the same amount of increase in technical execution (Ambroży dkk., 2021). This imbalance among the athletes may be explained by a number of reasons. Other athletes experienced that they felt stronger and more physically capable but they could not sustain the accuracy and speed they needed to execute their techniques at the highest level in simulated competitions. These athletes complained that they were having a hard time incorporating the new physical strength and endurance into their technique, which could be the reason behind the inconsistency of the performance results of the participants. The technical aspect of such execution may further be a result of the fact that technical abilities in combat sport such as Pencak Silat are not only based on physical training but also muscle memory, timing, and mind concentration. Physical benefits of HIIT may have not yet realized as consistent and high-level technical performance (Coates dkk., 2023). This is stressed by the results of Subekti and Warthadi (2022) and they state that it is hard to convert physical fitness gains to the enhancement of technical performance because it is also associated with long-lasting mental focus and pressure-resistant performance as well. Also, certain athletes might have been more technologically superior at starting the HIIT program, and others, especially the ones with lower experience, might have struggled to integrate the physical gains in their technical performance.

Also, it should be noted that the technical performance in the martial arts is complicated by nature and it involves a combination of physical power and stamina, as well as coordination of the motor activity. Although HIIT is proven to enhance the endurance and the strength, these changes should also be coupled with sport-specific technical exercises so that the athletes could be capable of using their physical achievements in the actual competition environment. This is in line with the past research on other combat sports, including boxing and wrestling, who exhibited physical conditioning improvements with the application of HIIT but still needed additional training that required technique-specific training to perfect their performance under the conditions of the competitions (Warthadi et al. 2022; Wajib et al. 2022). The results of the present research highlight the possible use of HIIT in improving endurance, strength, and technical performance among combat athletes. Nevertheless, they further indicate that further training, which would be sport specific to the technical requirements of the sport, is required to ensure that the physical changes due to the HIIT are fully maximised.

Although the findings of the present study can prove the effectiveness of HIIT in enhancing endurance and technical performance, some

limitations should be considered in future studies. To begin with, the sample size only comprised of male athletes in one university which restricts the ability to apply the study to a wider group of people. The proposed future research may include female athletes and participants who belong to various competitive levels or geographic areas to learn more about the potential of HIIT to influence the effect of the training on various groups of Pencak Silat participants. Furthermore, the research period was very brief, and it was six weeks. It would also be advantageous that future studies examine the prolonged impacts of HIIT, such as the possibility of extending its effect on performance and the sustainability of the same on performance past the course of intervention.

The interaction between physical conditioning and development of technical skills would be worth examining in greater detail. In particular, the interaction between HIIT and sport-specific technical training could be investigated to gain a deeper insight into the implementation of physical conditioning programs in conjunction with skill-based training in order to achieve the maximum performance. Lastly, psychological impacts of HIIT on athletes, such as confidence, motivation, and mental toughness, are also worth considering in the future research. As it has been demonstrated in this study, physical fitness enhancement may indeed lead to a certain increase in confidence though further investigation into how HIIT can affect people psychologically as combat athletes will be of great importance in determining the full potential of this training mode.

Comparasion With Previous Studies

When making comparisons that involve the results of this study with other research, there are a number of similarities and differences revealed in relation to methodology and results. Subekti and Warthadi (2022) researched the impact of HIIT on the physical performance of combat athletes and reported positive results in endurance and strength, which are consistent with the data of this research. The two studies propose that HIIT is useful in enhancing aerobic capacity, which is essential in maintaining energy during vigorous physical exercises such as Pencak Silat. Also, the studies conducted by Warthadi et al. (2022) and Nugroho and Kusuma (2022) allow concluding that HIIT results in the increase in combat sport strength and endurance. It is necessary to note that all of these studies are consistent with the results of this study, meaning that HIIT can be considered an effective type of physical conditioning of combat athletes.

Nevertheless, this is one aspect in which this work differs with the rest in the emphasis of subjective lives of the athletes. Whereas some of the past studies (including the one by Wajib et al. (2022)) have concentrated on the objective performance measures, including VO2max and strength endurance, the current research takes the aspect of understanding the perceptions of the athletes in relation to making improvements in physical conditioning and technical execution. The interviews were very informative in terms of the mental and emotional reaction of the athletes towards the training process and it turned out that the physical benefits were not the only, but the mental and psychological ones were prominent as well. This is a unique feature of the study that can offer a deeper understanding of the role of HIIT in confidence and inspiration of athletes in combat sports, which has not been properly addressed in the literature.

The other difference is the period and frequency of training. The research articles by Warthadi et al. (2022) and Khotimah et al. (2023) usually used shorter training programs that varied between four and six weeks, which are also relevant to this study. Nevertheless, longer training durations were tested with different outcomes in other studies, including those by Lubis et al. (2024). The results of this research are speculative that six weeks of HIIT are enough to observe significant gains in endurance and strength but might not be enough to attain significant long-term changes in technical performance. This makes one wonder the ideal duration of HIIT training in combat athletes and proposes the need to conduct future studies on the effects of longer HIIT training programs on physical conditioning as well as technical performance.

Limitations and Future Research Directions

Although, the outcomes of this study are encouraging, there are some critical limitations that should be tackled in the further study. A large limitation is the number of participants and the homogeneity. The sample size of the study is relatively small and it also included a group of male participants in one university which leaves the study with a narrow scope of process extrapolation to the general population of the Pencak Silat practitioners. It is also hard to suggest any conclusions about the effectiveness of HIIT among other groups of athletes because of the limited sample size and the absence of diversity regarding gender, the level of skills, and experience. As an example, this study did not include female athletes who might have various physiological and

psychological challenges during the training process. Future studies are needed to consider more and diverse sample of athletes with different regions, levels of competition, and demographics. The incorporation of athletes who belong to varied geographical locations and diverse experiences of competition will enable the researchers to ascertain whether the advantages of HIIT can be universal to Pencak Silat athletes or some groups of athletes enjoy greater advantages. Moreover, it is possible to think about the age and the level of skills as the factors that may help to realize how HIIT influences various groups of athletes, starting with beginners to professional participants.

The second point of consideration is the long-term outcomes of HIIT on athletic performance that should also be considered in the future research. In this paper, emphasis was laid on a six-week intervention process and, although the findings were very encouraging in terms of an increase in endurance, strength, and technical performance, the question of whether such an increase is maintained in the long run remains open. It might be possible that the advantages of HIIT may be exhausted after some time or that further training might result in additional progression. Hence, the further research may be supplemented with a more extended period of intervention (12 weeks and beyond) to explore the effects of whether these performance improvements are carried on or further improved. Moreover, it would be of help to understand how these benefits are retained even after completing the HIIT program. Follow-up research would be able to investigate the development of performance of athletes after returning their usual training programs and whether they are able to maintain the benefits of HIIT training regardless of the absence of high-intensity exercises.

The interaction of HIIT with other types of training could be investigated in the future. This paper was dedicated to HIIT as an independent intervention, though Pencak Silat, and most combat sports in general, demand a complex training design involving both physical training and acquisition of technique. HIIT might be used together with other training techniques like technical training, flexibility training or mental conditioning to give a complete training program to combat athletes. In such a way, technical exercises that focus on accuracy, speed, and tactics plus HIIT may lead to more significant overall performance gains, as muscle endurance will be paired with movement skills. It can be investigated by the researchers whether the synergistic effect can be achieved with an interplay of training modalities the physical benefit of HIIT will lead to the improvement of technical performance and vice versa. This strategy may assist in the formulation of an holistic training program that meets the special needs of the combat sports such as Pencak Silat.

The psychological effect of HIIT in athletes is another significant field that should be investigated in future. Although this paper dwelled on physical advantages of HIIT, psychological health and mental capacity of athletes are also crucial in the sphere of high intensity athletics. Though this study described the subjective experience of the athletes in interviews, the study lacked the in-depth analysis of the psychological phenomena of training. The psychological resilience, inspiration and belief of the athletes is foundational to their performance under stress particularly in the competitive environment. The question arises on whether HIIT training directly affects these psychological factors.

Besides the psychological preparation, it would be useful to investigate the direct association between an enhancement in physical performance and confidence at competition. By its nature, martial arts demand physical power as well as intellectual strength, and the intellectual parts of the training can be as important as the physical ones. It has been demonstrated that self-efficacy and belief in ability of an athlete can directly affect his/her performance in a competition. The following studies might use psychological assessment instruments and performance indicators to monitor the alterations in confidence, mental focus, and overall mental health as well as physical performance indicators to understand the interrelations between mind and body in combat sport training better. The other future research area could be to investigate the personal differences in response to HIIT.

The results of the athletes participating in this research were varied in the aspect of technical performance, as some indicated improvement of technical performance and others were unable to transfer physical accomplishments into perfect technical performance. It would also be advantageous to examine the factors which enable some athletes to be constantly able to use techniques of their performance on a high level whereas other athletes might have problems with combining strength and endurance with technical skills. Is it these differences in motor learning, prior experience or are they individual training backgrounds that cause these discrepancies? Further research may include a closer look into these factors, perhaps by measuring the learning styles of

the athletes, the mastery of technical skills, or the attitude towards training to realize which components make the combination of physical conditioning with technical performance successful.

Since the field of sports science is developing, biomechanical measurements might be helpful in providing more information about the effects of HIIT on particular movement patterns in Pencak Silat. With such instruments as motion capture or force sensors, future studies will be able to monitor the effect of HIIT on the efficiency and power of all important movements in martial arts, including punches, kicks, and defensive moves. This would assist in ascertaining whether HIIT has a direct impact on the biomechanics of such movements or further, more sport-specific training is required to refine the techniques of the athletes. The biomechanical data would be more knowledgeable when combined with the physical performance to demonstrate the effect of HIIT on Pencak Silat and other combat sports.

CONCLUSION

This paper has offered some important information on the efficacy of High-Intensity Interval Training (HIIT) as a process of boosting the stamina, strength, and technical efficiency of Pencak Silat athletes. The findings have clearly shown that HIIT can be used to a great extent to enhance the specific endurance and physical conditioning required to excel in a combat sport such as Pencak Silat. Athletes who underwent the HIIT program mentioned that they had improved cardiovascular endurance, increased strength and confidence of their ability to perform techniques in conditions that resembled that of a competition.

The fact that special training in combat sports is important is also made evident in this research. Although general conditioning is also a common approach in traditional training, this approach proved to be ineffective as the use of HIIT in this research showed that a specialized high-intensity training may result in significant changes in physical fitness and technique. The increase in endurance and especially high-intensity movements such as striking and kicking explain the applicability of HIIT to Pencak Silat where agility and endurance become very important to performance maintenance during a match. Moreover, the participants said that their technical performance had increased considerably, though it was also noted that mental and psychological processes, including confidence and concentration, are also critical issues to turn the physical gains into the positive performance.

This research has clearly shown the positive contributions of HIIT among the athletes of the Pencak Silat sport to the existing literature of support of the concept of high-intensity training protocols in combat sports. The results offer background to the further investigation that might investigate more prolonged HIIT intervention, psychological effect of this type of training, and the integration of HIIT in another type of skill-specific training methods. These spheres are promising in terms of streamlining training programs and improving more on athletic performance in Pencak Silat.

The effects that HIIT has on the athletic performance, as the study in question shows, are substantial, yet the way ahead is through further research. With the further development of combat sports and a more advanced training process, the introduction of specific interventions, such as HIIT, may be the key to the creation of an all-round athlete who will be able to perform at the highest level in the conditions of a highly competitive environment of martial arts sports. The possibility of HIIT to promote not only physical but also psychological resilience is one of the key aspects that should be given attention to in the future research which would unlock even more beneficial performance improvements among athletes in the future.

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