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Comparison of the Effects of LISS (Low-Intensity Steady State) and HIIT (High-Intensity Interval Training) on Cardiovascular Adaptation

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ABSTRACT

Introduction. Aerobic exercise plays an important role in improving cardiovascular fitness, but each training method has different effectiveness. This study aims to compare the effects of Low-Intensity Steady State (LISS) and High-Intensity Interval Training (HIIT) on cardiovascular adaptation in students from the Department of Physical Education, Health, and Recreation, Universitas Negeri Makassar (UNM). **Methods.** This study used an experimental method with a pre-test and post-test control group design. A total of 54 students were divided into two groups. The first group underwent LISS training with an intensity of 50-60% of maximum heart rate (HRmax) for 40 minutes per session, while the second group underwent HIIT with an intensity interval of 85-95% HRmax for 20 minutes per session, each performed 4 times per week for 6 weeks. The cardiovascular parameters measured included VO_2 max, resting heart rate, and systolic and diastolic blood pressure. **Results**. The results showed that both training methods provided a significant increase in VO_2 max and a decrease in resting heart rate ($p < 0.05$). However, the HIIT group experienced a greater increase in VO_2 max compared to the LISS group ($p < 0.05$), while the LISS and HIIT pressure reduction variables were significantly able to reduce systolic and diastolic blood pressure, indicating similar benefits in terms of blood pressure control**. Conclusion.** The conclusion of this study is that HIIT is more effective in increasing cardiovascular adaptation, more effective in heart performance or decreasing heart rate and both are effective in reducing systolic and diastolic blood pressure.

1. Introduction

Physical exercise plays an important role in maintaining cardiovascular health, training methods include LISS and HIIT. LISS is a form of exercise performed at a low intensity level continuously, while HIIT involves periods of high intensity exercise accompanied by a recovery phase. Studies have shown that engaging in regular physical exercise can significantly reduce the risk of cardiovascular disease and improve overall cardiovascular performance.[1,2] However, while both LISS and HIIT have demonstrated benefits for cardiovascular health, there remains a gap in understanding how these two methods compare in terms of long-term adherence, safety across different populations, and specific cardiovascular adaptations.

LISS, which often involves aerobic activity with a lower risk of injury, is considered easier for those who are unable to perform vigorous physical activity. This exercise has the same benefits in improving heart health in a more sustainable way and can be done by various age groups.[3,4] Based on research, LISS exercise has been shown to contribute to increased fat metabolism, which is important in weight management and prevention of cardiovascular disease.[5]

Furthermore, HIIT is useful in improving various risk factors for cardiovascular disease in a shorter time. Research indicates that HIIT can stimulate increased muscle mitochondrial capacity and glucose metabolism, which contributes to blood sugar control, especially for individuals with type 2 diabetes.[6] HIIT has also been shown to induce improvements in aerobic capacity in sedentary individuals over a short period of time.[7] It is important to consider the effects of both methods on different individuals, as well as the physiological adaptations they produce.[4,8] While HIIT has greater cardiovascular benefits in a shorter period of time, LISS can be performed by individuals who may have physical limitations.[9] Additionally, HIIT can be challenging to perform routinely without careful supervision, especially in participants who are not accustomed to intense exercise.[10] In conclusion, both

LISS and HIIT have benefits in cardiac rehabilitation programs and need to be tailored to meet the needs of individuals in effectively maintaining their cardiovascular health.[2,11]

HIIT has been studied in numerous studies over the past five years and has shown positive effects on the physiological adaptations of the cardiovascular system. HIIT is known for its high intensity and has been shown to be more effective in improving cardiorespiratory capacity compared to other training methods, including Moderate-Intensity Continuous Training (MICT).[12–14] Studies have shown that HIIT can significantly increase VO_2 max in a shorter time compared to continuous training.[12,15,16]

HIIT also plays an important role in reducing the risk of cardiovascular disease and improving overall health through improving cardiac autonomic control.[15] HIIT contributes to the reduction of visceral fat and increased oxygen volume, which are important aspects in improving body composition and heart function.[12,14] In addition, HIIT has also been shown to improve metabolic health, weight management, and function endothelial, which are key factors in the prevention of cardiovascular disease.[13,17]

Studies by Chen et al. have shown the positive impact of HIIT on cardiovascular health in adult populations, especially in the context of improving cardiovascular fitness and reducing risk factors.[18] Meanwhile, Plizga et al. emphasize the importance of the effectiveness of HIIT in the context of long-term health, including its effects on blood pressure and lipid metabolism, all of which contribute to better cardiovascular health.[13,17]

LISS has significant health benefits, especially in the context of long-term endurance and affordability for individuals across demographics. LISS is generally more psychologically acceptable to many individuals, as its lower intensity makes it easier to integrate into daily routines. It can also significantly improve physical and mental health, even without the same intensity as HIIT. In addition, different training methods can have different impacts on health.[19] Safety and convenience are key reasons why individuals prefer LISS. With a lower risk of injury compared to HIIT, LISS is suitable for beginners or individuals with certain health conditions who may be concerned about the potential for injury when performing more intensive training. While LISS is less effective at increasing VO_2 max compared to HIIT, it still provides significant cardiovascular benefits and creates a better quality of life for previously inactive individuals.[20]

LISS involves low-intensity activity performed continuously for a longer duration, making it a more comfortable option for some individuals, which may facilitate long-term adherence to an exercise program. Based on the findings of Merola et al., individuals participating in a LISS program still experienced cardiovascular benefits, although these results were not in line with the effects produced by HIIT.[21] This suggests that while LISS may not be as intense as HIIT in terms of improving aerobic fitness, its long-term benefits to cardiovascular health and comfort for exercisers should be considered in the context of a broader fitness program.

Understanding the differences in effects between LISS and HIIT can help lecturers, coaches, and practitioners of physical education and sports to prepare students to implement more effective and safe exercise programs. The main thing to note is that students do not just train without knowledge, but also understand the physiological mechanisms behind the exercise they are doing, which aims to strengthen the heart and blood vessel system. The purpose of this study was to compare the effects of Low-Intensity Steady State (LISS) and High-Intensity Interval Training (HIIT) on specific indicators of cardiovascular adaptation, such as heart rate, VO_2 max, and blood pressure. Through this research, it is hoped that it can provide useful insights in developing effective cardiovascular training programs for students in an effort to improve overall health and physical performance.

2. Methods

This study used an experimental design with a pretest-posttest control group approach. This design was chosen to compare the effects of two types of exercise, namely LISS and HIIT Exercise, on cardiovascular adaptation in students from Department of Physical Education, Health, and Recreation. Both types of exercise were carried out under the supervision of certified trainers to ensure participant safety, consistency of implementation, and proper execution of exercise techniques throughout the intervention period.

A total of 54 students will be divided into two experimental groups, namely the group that will undergo the LISS exercise program and the other group will undergo the HIIT exercise program. Measurements of VO_2 max, heart rate, and blood pressure were carried out before and after the exercise program period to analyze the cardiovascular adaptations that occurred.[22] The sample size was determined based on statistical power analysis using G*Power software. With an effect size set at a medium level ($f = 0.25$), alpha level of 0.05, and desired power of 0.80, a minimum of 52 participants was required to detect significant interaction effects in a repeated measures ANOVA design. Therefore, a total of 54 participants were recruited to account for possible dropouts and ensure sufficient statistical power.

Participants were randomly assigned to either the LISS or HIIT group using a computer-generated randomization process. After all eligible students provided informed consent, their names were entered into a list and randomly allocated to the two groups using a random number generator. This

procedure ensured that group assignment was unbiased and minimized the risk of selection bias. The randomization was conducted by an independent researcher who was not involved in the data collection or intervention delivery to further ensure objectivity. This random allocation process was essential to balance potential confounding across both groups, thereby increasing the internal validity of the study.

Research subjects

The study population consisted of students of Department of Physical Education, Health, and Recreation, Universitas Negeri Makassar (UNM) students who were actively registered in the study program during the 2024-2025 academic year. Exclusion criteria in this study included students who had a history of cardiovascular disease, were undergoing medication that could affect cardiovascular function, or had other medical conditions that could interfere with participation in the training program. In addition, students who were unable to commit to attending all training sessions or who showed inconsistent attendance were also excluded from participating in the study. These criteria were applied to ensure subject homogeneity and the validity of the study results.

Exercise intervention

The exercise sessions will be held for 6 weeks with a frequency of 4 times a week.

1. LISS Exercise: Includes aerobic activity such as cycling or light jogging for 40 minutes at 50-60% of the participant's maximum heart rate (HRmax).
2. HIIT Exercise: Includes interval activity, where participants perform exercise with an intensity interval of 85-95% HRmax for 20 minutes per session.

Variable measurement

Data collection was carried out in two stages: before the intervention (pretest) and after the intervention (posttest).

1. VO_2 max: Measured using the Cooper Test which is then analyzed to determine the participant's aerobic capacity.
2. Resting Heart Rate: Measured using a heart rate monitor recorded in a resting condition for 5 minutes before exercise in each measurement session.
3. Blood Pressure: Measured using a manual sphygmomanometer or automatic blood pressure monitor in a relaxed sitting condition after 5 minutes of rest, both before and after the training period.

Data analysis

The data obtained will be analyzed using statistical programs, such as SPSS (Statistical Package for the Social Sciences). To compare the differences in results between the two groups, t-test was used according to the data distribution. Significant results were determined at the level of $p < 0.05$.

Research ethics

Before starting the study, all participants will be asked to sign an informed consent after receiving an explanation of the purpose, methods, and potential risks of the study. This study has passed ethical observation with Number: 557/H4.8.4.5.31/PP36/KOMETIK from RSPTN Universitas Hasanuddin to ensure all rules to protect research participants are followed.

3. Results

Measurement data of VO_2 max, resting heart rate, and blood pressure were collected from two groups of LISS and HIIT. The results of these measurements were analyzed using analysis of variance (ANOVA) or t-test to investigate significant differences between the two groups (Table 1).

Based on Table 1, HIIT shows a very significant increase from 45.0 ± 3.2 ml/kg/minute to 52.5 ± 3.8 ml/kg/minute, with a p value <0.05. This figure indicates that HIIT is very effective in increasing VO2 max and, in other words, has a major impact on an individual's cardiorespiratory capacity. On the other hand, LISS also shows an increase, although with more moderate results, from 44.0 ± 2.9 ml/kg/minute to 47.0 ± 3.1 ml/kg/minute, and with a p value of <0.05. Although the increase in LISS clearly shows effectiveness in increasing aerobic capacity, the results are not as strong as the effects shown by HIIT. Therefore, it can be concluded that although both training methods are able to increase VO_2 max, HIIT provides greater benefits than LISS in the context of developing an individual's aerobic capacity.

Table 1. Measurement data of VO_2 max, resting heart rate, and blood pressure in the LISS and HIIT groups

Parameters	Groups	*Pretest* (Mean ± SD)	*Posttest* (Mean ± SD)	P* Value
VO_2 max (ml/kg/minute)	HIIT	45.0 ± 3.2	52.5 ± 3.8	< 0.05
	LISS	44.0 ± 2.9	47.0 ± 3.1	< 0.05
Resting heart rate (bpm)	HIIT	75 ± 4.5	68 ± 4.2	< 0.05
	LISS	74 ± 3.8	72 ± 3.6	> 0.05
Systolic blood pressure (mmHg)	HIIT	127.9 ± 9.7	119.3 ± 9.2	< 0.05
	LISS	128.4 ± 10.5	122.1 ± 9.8	< 0.05
Diastolic blood pressure (mmHg)	HIIT	83.2 ± 7.4	80.5 ± 6.9	< 0.05
	LISS	82.7 ± 7.1	78.1 ± 6.4	< 0.05

Resting heart rate changes in students who participated in the exercise program showed that HIIT resulted in a significant decrease in resting heart rate, from 75 ± 4.5 bpm to 68 ± 4.2 bpm, with a P value < 0.05. This decrease indicates that HIIT has a positive effect on reducing resting heart rate, an important indication of increased cardiovascular efficiency and potential long-term health benefits. In contrast, the LISS program did not show any significant changes in resting heart rate, with a p value > 0.05, indicating that the LISS intervention did not have a strong enough impact to change this physiological parameter.

The results of the study related to systolic blood pressure showed that both HIIT and LISS had a positive impact on reducing systolic blood pressure. In this study, the group that underwent HIIT showed a significant decrease in systolic blood pressure from an average of 127.9 ± 9.7 mmHg to 119.3 ± 9.2 mmHg, with a p value < 0.05, indicating that the change was unlikely to occur by chance. The group associated with LISS also experienced a significant decrease, from 128.4 ± 10.5 mmHg to 122.1 ± 9.8 mmHg, with a p value also <0.05. This finding confirms that both exercise methods, although different in intensity, are equally effective in lowering systolic blood pressure.

This study stated that post-intervention diastolic blood pressure values showed a significant decrease, where the HIIT group experienced a decrease from 83.2 ± 7.4 mmHg to 80.5 ± 6.9 mmHg with a p value <0.05. Likewise, the LISS group also showed a significant decrease, from 82.7 ± 7.1 mmHg to 78.1 ± 6.4 mmHg, with a p value <0.05. These results indicate that both exercise methods are effective in reducing diastolic blood pressure.

4. Discussion

a. Effect of LISS and HIIT training on VO_2 max

LISS and HIIT are both effective in increasing VO_2 max, but through different adaptation pathways. LISS increases cardiovascular efficiency and muscle capillarization gradually, suitable for beginners and individuals with physical limitations. In contrast, HIIT provides a more rapid increase in VO_2 max through increased cardiac stroke volume and oxygen utilization efficiency, ideal for active individuals or athletes. The combination of the two may be an optimal strategy for improving cardiovascular fitness.

The results of the study showed that both types of training, LISS and HIIT, can improve cardiovascular adaptation. However, HIIT is superior in improving aerobic capacity and cardiac efficiency. This finding is in line with previous studies that prove that HIIT produces a more significant increase in VO_2 max compared to low-intensity training methods. In a study by Andreato et al. it was revealed that HIIT provides a significantly greater increase in VO_2 max, which is an average of 5.3 mL/kg/min, compared to MIIT (Moderate-Intensity Interval Training) which only reaches 2.5 mL/kg/min.[23] This is in line with a systematic review by Yue et al., which shows that HIIT can significantly improve cardiac output and stroke volume in the context of cardiac rehabilitation. HIIT performed in a short time with an intense training package, encourages the body to adapt to greater metabolic stress, resulting in a more efficient cardiovascular reaction.[24]

b. Effect of LISS and HIIT training on heart rate

A significant decrease in resting heart rate in the HIIT group indicates improved cardiac adaptation and enhanced parasympathetic tone. This adaptation process involves increased cardiac pumping efficiency and improved cardiac regulatory mechanisms that generally reduce resting heart rate requirements. Cardiac adaptations caused by High-Intensity Interval Training (HIIT) training have been the focus of research considering the physiological effects of this exercise.

A significant decrease in resting heart rate is a positive indicator of cardiac efficiency and increased parasympathetic tone. Research by Fauzia et al. stated that HIIT can improve cardiac hemodynamic function, which contributes to strengthening the heart muscle and is expected to reduce resting heart rate.[25] In addition, the effect of HIIT on cardiac adaptation occurs because this exercise increases the efficiency of the heart's blood pumping, which can reduce the heart's need to contract at high frequencies at rest and increase oxygen uptake.[26]

Other studies have shown that HIIT not only improves cardiac endurance but also improves the overall efficiency of the cardiovascular system. Research by Amalia et al. showed that regular physical activity can strengthen the heart muscle and increase the elasticity of blood vessels, which contributes to the balance of parasympathetic tone and a decrease in resting heart rate.[27] In addition, research by Daulay et al. found that individuals who underwent HIIT experienced a significant increase in VO_2 max, which is a measure of the efficiency of the heart and respiratory system, and this can be directly related to a decrease in resting heart rate. [26]

c. Effect of LISS and HIIT training on blood pressure

Both HIIT and LISS significantly reduced systolic and diastolic blood pressure, showing similar benefits in blood pressure control. Although both exercise methods are beneficial for cardiovascular health, HIIT produced more prominent results in improving aerobic capacity and cardiac efficiency.

HIIT not only serves as a method to increase physical capacity but also has an important role in creating better physiological adaptations in the heart, proving that this exercise model may be beneficial in cardiac rehabilitation programs and the prevention of cardiovascular disease.[28] Meanwhile, the decrease in systolic blood pressure in the HIIT group indicates a significant improvement in cardiovascular health. The decrease in blood pressure associated with HIIT

contributes to a reduction in the risk of hypertension, one of the main factors in the development of cardiovascular disease. Previous studies have also suggested that HIIT training is beneficial in lowering blood pressure; this may be related to changes in the autonomic nervous system and increased arterial elasticity.

High-Intensity Interval Training (HIIT) has cardiovascular benefits, particularly in controlling systolic blood pressure and overall cardiovascular health. Studies have shown that participating in HIIT can lead to significant reductions in SBP. For example, a systematic review found that HIIT is effective in improving carotid artery compliance and baroreflex sensitivity, which can lower blood pressure in hypertensive patients.[17] This reduction in blood pressure is essential for reducing the risk of hypertension—a major risk factor for cardiovascular disease.[17,29] The underlying mechanisms by which HIIT affects blood pressure include improved endothelial function and increased nitric oxide availability, which improves vascular health.[17,30] HIIT has been shown to reduce sympathetic nervous system activity, reflected in decreased muscle sympathetic nerve activity (MSNA) levels, which may explain the observed reduction in SBP.[30]

Additionally, studies have shown that HIIT results in changes in arterial stiffness, suggesting that the training session effectively improves vascular elasticity.[31] Further supporting these findings, a meta-analysis showed that HIIT can reduce both systolic and diastolic blood pressure while improving other cardiovascular risk factors such as metabolic parameters and lipid metabolism.[29] Specifically, participants with baseline hypertension showed significant reductions in SBP following HIIT intervention, suggesting its role in managing and potentially reversing hypertensive conditions.[30]

The benefits of HIIT are also due to efficient calorie expenditure and its role in achieving significant adaptive changes in the cardiovascular system in a shorter training period compared to moderate-intensity continuous training (MICT).[32] The metabolic modifications and improvements in cardiovascular fitness offered by HIIT contribute to its effectiveness in reducing the risk of cardiovascular events.[29,32] HIIT has been shown to be an effective intervention to significantly lower systolic blood pressure and improve cardiovascular health as part of a tailored exercise program for hypertensive individuals. The physiological adaptations resulting from HIIT, such as increased arterial elasticity and endothelial function, are in line with broader strategies to reduce the risk of cardiovascular disease.

From a practical perspective, the results of this study have implications for exercise programs designed for students of Department of Physical Education, Health, and Recreation, Universitas Negeri Makassar (UNM). Lecturers and trainers can consider using HIIT as the main training method in improving students' cardiovascular fitness, given the more efficient time and faster results compared to LISS. However, it is also important to consider individual preferences, especially in determining the type of exercise a student will engage in. LISS may be more appropriate for individuals who are focused on long-term endurance training or who are at higher risk for injury. Additionally, the low intensity of LISS allows participants who are not accustomed to vigorous exercise to participate in the exercise program comfortably and safely.

However, this study also has several limitations that should be acknowledged. The relatively short duration of the intervention may not fully capture long-term adaptations to HIIT or LISS training. Additionally, there was a lack of dietary control, which could have influenced the results, particularly in relation to blood pressure changes. The use of the Cooper test to assess aerobic capacity, while practical, may not be as accurate as direct VO_2 max testing, potentially limiting the precision of the findings. Furthermore, participants' physical activities outside the supervised training sessions were not controlled or monitored, which could have introduced additional variability in the outcomes. These uncontrolled external factors may have influenced both cardiovascular responses and fitness improvements, and should be taken into consideration when interpreting the results and their application to broader exercise programs.

5. Conclusion

Both HIIT and LISS training had positive effects on increasing aerobic capacity and cardiovascular physiological parameters. However, HIIT was shown to be more effective than LISS in significantly increasing VO_2 max and decreasing resting heart rate, indicating increased cardiovascular efficiency. Both HIIT and LISS significantly decreased systolic and diastolic blood pressure, indicating similar benefits in terms of blood pressure control. Therefore, although both training methods are beneficial for cardiovascular health, HIIT provides more prominent results in increasing aerobic capacity and cardiac efficiency.

This study supports the recommendation of using HIIT in training programs to improve heart and cardiovascular health. Further studies with larger samples and longer training periods are expected to provide additional information on the long-term effects of these two types of training.

6. Author Contribution

The author conceived the initial idea, planned and conducted the experiments, selected samples, wrote the manuscript with scientific discussion support from colleagues, and supervised the entire research project.

7. Acknowledgements

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