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The Effect of Active and Passive Cooling Down Exercises on Reducing The Pulse Heart Rate of Female Volleyball Athletes

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Abstract

Introduction: A decrease in pulse rate is the most important part that can be measured to support the effectiveness of the training program. In volleyball, which requires a long game time, coaches must also know the process of effective and efficient cooling exercises that can be used to lower the pulse rate. Cool-down training is one way to reduce the pulse rate. **Objectives:** This study aims to measure the effects of active and passive cooling exercises on physiological responses, one of which is pulse rate. **Method:** The method used in this study is a quantitative method with an experimental approach with a research design of a two-group pre-test post-test design. The population in this study was Female Volleyball Athletes of Club Bahana Bina Pakuan Bandung City, with an age group of 15-17 years, many of 16 people. The sampling technique used was total sampling, with a total population of 16 people who became the research sample. The instrument used is a Polar H10 device to measure the pulse rate that drops when given active and passive cooling exercises. **Result:** The results of this study indicate that a more significant decrease in pulse rate is achieved when using active cooling exercises; the effectiveness obtained is 5.70%, whereas passive cooling exercises result in a significant decrease by 3.68%. **Conclusion:** This study provides recommendations for coaches to continue to see the decline that occurs when given a cooling exercise program. It is also expected that coaches have polar devices to monitor the condition of athletes.

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INTRODUCTION

In sports clubs such as volleyball, training programs are one of the most important aspects that must be designed and organized in such a way as to make it easier for coaches to see improvements in athletes' performance and the stages of training (Mika et al., 2016). Cool-down exercises are part of the recovery routine to observe the decrease in heart rate that occurs during the cool-down session. Cool-down exercises are a session where the heart rate decreases to its normal or resting state, as achieving a return to normal heart rate is crucial, supported by the quality of the cool-down training program (Tschentscher et al., 2016). A good cooling-down exercise program can enhance an athlete's performance and improve the body's physiological adaptation to the physical activities they perform (Parks et al., 2022).

The decrease in heart rate is ineffective because the cool-down exercise program is not structured or is monotonous, resulting in an ineffective and unstructured decrease in heart rate (Barcala-furelos et al., 2016). Coaches or athletes often overlook the importance of measuring heart rate reduction after exercise, as it is not considered a priority during training. It is possible that coaches are unaware of the importance of proper heart rate reduction as a benchmark for exercise programs (Manonelles, 2021). Factors that arise when cooling-down exercises are not performed include ineffective cooling-down exercise programs, such as performing individual cooling-down exercises, which result in the heart rate decrease not being monitored (Arslan et al., 2017). Another factor is that coaches may not fully understand the importance of cool-down exercises for lowering heart rate, as they may not fully grasp the sequence of cool-down exercises or may not be sports practitioners themselves (Purnamasari et al., 2022). Additionally, monotonous training programs, such as only jogging after exercise, can lead to athlete burnout, making it difficult to observe the percentage of heart rate reduction (Abou et al., 2024).

Previous studies have shown that active and passive cooling-down exercises can help restore heart rate, as measured one minute after completing a set or a series of exercises (Farinelli et al., 2021). This shows that a well-planned cool-down program is important to help reduce the pulse of heart rate effectively in volleyball, where athletes often face high-intensity rallies that increase heart rate significantly. Maintaining good heart rate recovery not only supports cardiovascular health but also prevents overtraining and helps players (Sági et al., 2021). he decrease in heart rate after exercise typically ranges from 12 to 20 beats per minute within one to two minutes, which reflects the balance of the sympathetic and parasympathetic nervous systems and overall fitness (Peçanha et al., 2018) In the context of periodization, coaches should pay more attention to the heart rate recovery process, especially during the transition period, when the primary goal is recovery and regeneration after competition and the preparation period, where the improvement of the athlete's cardiovascular base serves as the foundation for the next phase of training. Evidence supporting this suggests that structured cool-down exercises during these periods help optimize recovery, prevent injuries, and maintain physical readiness for upcoming competitions (Hooren, 2018).

Factors influencing an increase in heart rate include physical activity, anxiety, caffeine consumption, or the use of certain medications (Abdurachman et al., 2016). The factors influencing heart rate are: 1) age, 2) gender, 3) body position, 4) physical activity performed (Aisyah et al., 2021). However, in this study, the author aims to investigate the effectiveness of the exercise program designed in such a way that it can reduce heart rate to normal levels quickly

At the county, city, or provincial level sports clubs in Indonesia, many still do not pay attention to accurately measuring heart rate, using Polar heart rate technology to effectively monitor changes in heart rate during exercise. In previous studies, many cooling-down exercise programs have been used to measure flexibility, injury recovery, or the effects of fatigue itself, which are measured using heart rate (Hooren, 2018). Evidence that active cooling-down exercises can influence athletic performance is still limited, as active cooling-down exercises do not always significantly improve athletic performance or reduce the risk of injury. This study focuses on the specific effects of active and passive cooling-down exercises on physiological responses, particularly heart rate, measured using the Polar Heart Rate H10 device (Bertollo et al., 2018). This study examines how the response to a cool-down exercise program can influence heart rate reduction in volleyball, and can also assist coaches in assessing physical condition factors such as endurance to determine the intensity for designing training programs (Peçanha et al., 2018).

Based on the research conducted by the author, the author aims to investigate the differences between active and passive cooling-down exercise programs, which may influence heart rate reduction after exercise, and claims that such programs can effectively reduce heart rate (Vegte et al., 2018). This study includes claims regarding heart rate reduction aided by specific active and passive cooling exercise programs, which will be consulted with physical conditioning experts. This research can educate that heart rate reduction can also indicate cardiovascular health, and it can also help coaches design effective physical training programs for athletes (Baxter et al., 2017). With this research, coaches or athletes can design and implement cooling-down exercise programs and monitor heart rate reduction measurements using a Polar heart rate monitor. Coaches should pay more attention to the design and monitoring of heart rate reduction itself.

METHOD

This study used an experimental method with a two-group pretest-posttest design involving two experimental groups. Each group received different treatments, namely active cooling exercises and passive cooling exercises, with heart rate measurements taken using Polar instruments before and after treatment.

A training program is a set of planned exercises designed by the coach to be given to athletes for each training session (Syamsuryadin & Wahyuniati, 2017). The active cooling exercises in this study consisted of low-intensity activities such as slow jogging and dynamic stretching for major muscle groups, carried out according to training norms with a duration of 30–60 seconds per movement, performed in 2 to 4 sets per movement, with a total cool-down duration of 5–10 minutes (Mackiewicz, 2018). The passive cooling exercises consisted of static stretching in a lying or sitting position, deep breathing, and complete rest without movement, with a duration of 15–30 seconds per movement, performed in 1 to 3 sets per movement, with a total duration of 5–15 minutes (Mackiewicz, 2018). The cool-down program designed for both active and passive cooling exercises was reviewed, consulted, and analyzed by a physical conditioning expert to ensure its suitability for volleyball athletes. The study population consisted of 16 female volleyball athletes from the Bahana Bina Pakuan Volleyball Club aged 15–17 years who underwent the same training program, using total sampling technique. The groups were randomly assigned based on similar age ranges and physical conditions, so that the 16 athletes were evenly divided into two groups of eight. One group received an active cooling exercise program, while the other group received a passive cooling exercise program. The measurement instrument used was the Polar Heart Rate device, which has been proven to be valid (0.95) (Schaffarczyk et al., 2022) and reliable (0.996) (Bell, 2023). The research procedure included device installation, a 15-minute warm-up, a 90-minute main training session, and a 10-minute cool-down session while observing changes in heart rate using the Polar Team app (Andriana et al., 2022). The active and passive cool-down exercise program was designed based on exercise norms and consulted with a physical conditioning expert, and was conducted over 4 weeks with a frequency of twice a week (van Hooren & Peake, 2018). The effectiveness of the exercise was measured by the difference in heart rate between the end of the core exercise and after the cool-down, to determine the fastest and most efficient method for reducing athletes' heart rates. The data obtained were analyzed using SPSS version 24.The data obtained were analyzed using SPSS version 24, with statistical procedures including descriptive statistics, normality tests, homogeneity tests, and paired sample t-tests to determine the significance of differences before and after the cooling-down treatments

RESULT AND DISCUSSION

Result

Based on the results obtained from field data collection, researchers must reprocess the data to obtain standard data. Therefore, the data must be processed using Microsoft Excel and Statistical Product and Service Solution (SPSS) version 25 (Jalolov, 2024).

Table 1. Demographic Data of Active and Passive Cooling Training Groups

Group	Age (Years)	Maximum Heart Rate (Beats Per Minute)
Active cooling	15,75 ± 0,463	204 ± 0,463
Passive cooling	15,63 ±0,518	204 ± 0,518

Based on Table 1, the average age of the active cooling group sample was 15.75 with a standard deviation of 0.463, while the average age of the passive cooling group sample was 15.63 with a standard deviation of 0.518. The average maximum heart rate in the active cooling group was 204 with a standard deviation of 0.463. The average maximum heart rate in the passive cooling group was 204 with a standard deviation of 0.518.

Table 2 Descriptive Statistics of the Sample Data for the Active and Passive Cooling Exercise Groups

Group	Test	Implementation of Cooling Exercises	Min.	Maks.	Amount	Mean	Standard Deviation
Active cooling	Beginning	Before	161	184	1.380	173	7,111
		After	98	121	856	107	8,298
		Difference	55	83	524	66	10,100
	End	Before	169	181	1.404	176	4,840
		After	82	112	787	98	8,798
		Difference	65	97	617	77	10,357
Passive cooling	Beginning	Before	162	178	1.357	170	5,476
		After	94	107	807	101	4,257
		Difference	56	75	550	69	6,159
	End	Before	175	170	1.402	175	3,845
		After	96	103	792	99	2,449
		Difference	69	79	572	76	4,496

Description: Initial and Final Test Scores, Pulse Rate Measurement Before and After Cooling Down Exercises

Based on Table 2, the results of the 8 active cooling exercise samples during the initial test data collection showed that before cooling, the minimum heart rate was 161, the maximum was 184, the total number of beats per minute from the 8 samples was 1,380, with an average of 173, and a standard deviation of 7.111. After performing cooling, the minimum heart rate was 98, the maximum was 121, the total number of beats per minute from the 8 samples was 856, with an average of 107, and a standard deviation of 8.298. The difference in cooling the heart rate was a minimum of 55 and a maximum of 83. The total number of beats per minute from the 8 samples was 524, with an average of 66 and a standard deviation of 10.100. Furthermore, the results of the 8 samples of active cooling exercises during the final test data collection showed that before cooling, the minimum heart rate was 169, the maximum was 181, the total number of beats per minute from the 8 samples was 1,404, with an average of 176, and a standard deviation of 4.840. After performing cooling, the minimum heart rate was 82, the maximum was 112, the total number of beats per minute from the 8 samples was 787, with an average of 98, and a standard deviation of 8.798. The difference in cooling the heart rate was a minimum of 65 and a maximum of 97. The total number of beats per minute from the 8 samples was 617, with an average of 77 and a standard deviation of 10.357. The results for the group of 8 samples during passive cooling at the time of the initial test data collection, before cooling, showed a minimum heart rate of 162, a maximum of 178, a total of 1,357 beats per minute across the 8 samples, with an average of 170, and a standard deviation of 5.476. After cooling, the minimum heart rate was 94, the maximum was 107, the total number of beats per minute from the 8 samples was 807, with an average of 101, and a standard deviation of 4.257. The difference in cooling the heart rate was a minimum of 56 and a maximum of 75. The total number of beats per minute from the 8 samples was 550, with an average of 69 and a standard deviation of 6.159. Furthermore, the results of the 8 samples of passive cooling exercises during the final test data collection showed that before cooling, the minimum heart rate was 170, the maximum was 181, the total number of beats per minute from the 8 samples was 1,402, with an average of 175, and a standard deviation of 3.845. After performing cooling, the minimum heart rate was 96, the maximum was 103, the total number of beats per minute from the 8 samples was 792, with an average of 99, and a standard deviation of 2.449. After cooling, the minimum heart rate was 69, the maximum was 83, the total number of beats per minute from 8 samples was 610, with an average of 76, and a standard deviation of 4.496.

Table 3. Percentage of Heart Rate Decrease During Cool-Down Exercise

Group	Test	Percentage	Difference
Active cooling	Beginning	32,11%	5,70%
	End	37,81%	
Passive cooling	Beginning	33,70%	3,68%
	End	37,38%	

Description: Percentage Difference in Heart Rate Decrease

Based on Table 3, there is a percentage of effectiveness from the treatment given during 8 sessions. The data results explain that the initial test on active cooling exercises was 32.11% and the final test was 37.81% with a difference in the success of the decrease of 5.70%. Furthermore, the initial test on passive cooling exercises was 33.70% and the final test was 37.38%, with a difference in reduction success of 3.68%.

Table 4. Normality Test Results

Group	Test	Statisitk	df	Sig.
Active cooling	Beginning	0,910	8	0,353
	End	0,910	8	0,356
Passive cooling	Beginning	0,891	8	0,239
	End	0,969	8	0,893

Based on Table 4, statistical analysis using Shapiro-Wilk was used to evaluate the normality of heart rate decrease data with a sample size of 16 people. The results show the extent to which the data is normally distributed. In the normality test, if the sig value is ≥ 0.05, the data is considered normal; if the sig value is ≤ 0.05, the data is considered non-normal. In the initial test data, the active cooling group had a statistical value of 0.910 df 8, with a sig value of 0.353. Since the sig value of 0.353 is ≥ 0.05, the data is considered normally distributed. In the final test data, the active cooling group had a statistical value of 0.910 df 8, with a sig value of 0.356. Since sig 0.356 ≥ 0.05, the data is considered normally distributed. In the initial test data, the passive cooling group had a statistical value of 0.891 df 8, with a sig value of 0.239. Since sig 0.239 ≥ 0.05, the data is considered to be normally distributed. In the final test data, the passive cooling group has a statistical value of 0.969 df 8, with a sig. value of 0.893. With a sig. value of 0.893 ≥ 0.05, the data is considered to be normally distributed.

When viewed as a whole, the data has a sig. value ≥ 0.05, so H0 is accepted, and all data are normally distributed. The results of this normality test also indicate that the distribution is normal for each variable. If the normality test results show that the data are normal, the researcher will then perform a paired sample T-test. Before conducting the paired sample T-test, a homogeneity test is performed first.

Table 5. Homogeneity Test Results

Result	*Levene Statistic*	df1	df2	Sig.
Based on Mean	1,438	3	28	0,253
Based on Median	1,369	3	28	0,273
Based on Median and with adjusted df	1,369	3	20,187	0,281
Based on trimmed mean	1,429	3	28	0,255

Based on Table 5, the homogeneity test obtained in all groups has a sig. value ≥ 0.05, so H0 is accepted and the data is declared homogeneous. After being declared homogeneous, the researcher will then test the hypothesis using a simple paired T-test.

Table 6. Results of Paired Sample T-test for Active Cooling Exercise Group

N	Mean	Standard Deviation	t	df	.Sig (<2-tailed)	Description
8	33,438	5,585	23,947	15	0,000	Signifikan

Based on Table 6, the results of the paired sample T-test on the decrease in heart rate given active cooling exercises obtained a sig.0.000 value, so H0 was rejected and H1 was accepted. Thus, it can be concluded that there was a change in heart rate decrease in the sample given active cooling exercises.

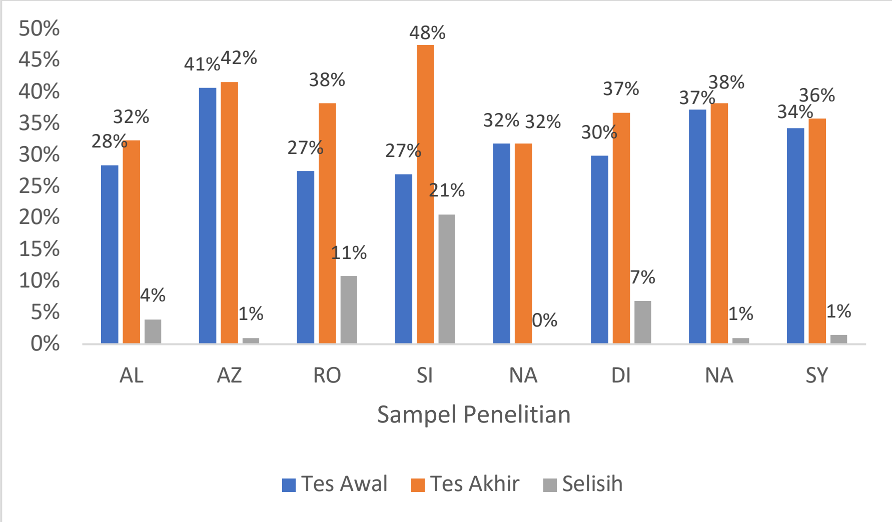

Figure 1. Percentage of Active Cooling Exercises and Differences

Based on the graph 1, the results of the initial and final tests, as well as individual differences among female volleyball athletes, show an increase in the final test. Therefore, it can be concluded that active cooling exercises can increase the decrease in heart rate in female volleyball athletes.

Table 7. Results of Paired Sample T-test for Passive Cooling Exercise Group

N	Mean	Standard Deviation	t	df	.Sig (<2-tailed)	Description
8	32,000	3,077	41,602	15	0,000	Signifikan

Based on Table 7, the results of the paired sample T-test on the decrease in heart rate given active cooling training obtained a Sig value of 0.000, so H0 was rejected and H1 was accepted. Thus, it can be concluded that there was a change in heart rate decrease in the sample given passive cooling training treatment.

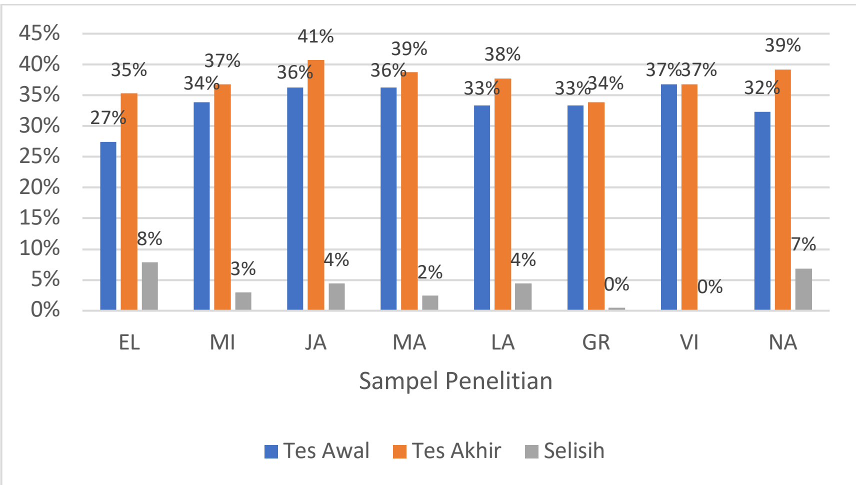

Figure 2 Percentage of Passive Cooling Exercise and Difference

Based on the graph 2, the results of the passive test at the end of the test and individual differences in female volleyball athletes showed an increase at the end of the test, so it can be concluded that passive cooling exercises can increase the decrease in heart rate in female volleyball athletes.

Table 8. Independent Sample T-test Results More significant

Group	Total	Mean	Standard Deviation	.Sig (2-Tailed)	Description
Active cooling	8	37,88	5,249	0,856	More significant
Pendinginan Pasif	8	37,50	2,268	0,857	Significant

Based on Table 8, the results of the independent sample T-Test comparison show that the active group has an average value of 37.88, a standard deviation of 5.249, and a significance value of 0.856 < 0.05, so H0 is accepted and H1 is rejected. For the passive group, the mean value is 37.50, the standard deviation is 2.268, and the significance level is 0.857 > 0.05, so H0 is accepted and H1 is rejected.

The limitations of this study are that it only examines the extent to which the exercise program designed to lower heart rate is effective, with an active heart rate reduction of 5.70% and a passive cooling reduction of 3.68%. If both exercises can lower heart rate, it would be even more effective for future researchers to combine the two cooling groups into one treatment.

Discussion

This study aims to determine and examine whether there is an effect of active and passive The results of the data analysis show that both active and passive cooling exercises have a significant effect on lowering the heart rate of female volleyball athletes. However, active cooling exercises were proven to reduce heart rate faster and more efficiently, with an average difference of 5.70% compared to 3.68% in the passive group. This indicates that structured active cool-down exercises should be prioritized by coaches to optimize cardiovascular recovery and maintain athletes' performance after training. cooling exercises on the reduction of heart rate in female volleyball athletes, and to observe the differences in heart rate reduction when active and passive cooling exercises are administered. This study involved two experimental groups with different exercise programs. The data analysis results showed that there was a significant effect between the two groups, where the active cooling exercise experimental group had a better reduction in heart rate compared to the passive cooling exercise experimental group. In this study, there were advantages during the research, but there were also drawbacks, one of which was that the equipment malfunctioned midway through the exercise, forcing the athletes to replace the equipment first during the exercise, resulting in some athletes having to take additional rest breaks.

In this study, the researchers discussed the decrease in heart rate that occurred as a result of significant active and passive cooling exercises in accordance with the training, starting from the selection of movements that were appropriate for the muscles used during training. The effects of the different experiments provided insight to the researchers regarding the training program that could be used during training to support effective and efficient heart rate reduction.

The Effect of Active Cooling Exercises on Heart Rate Decrease in Female Volleyball Athletes

Based on the results of the study conducted by the researchers, the data showed significant changes in the active cooling exercise experimental group. Active cooling exercises were found to be more effective than passive cooling exercises, as the body continues to move slowly at a light intensity after exercise, adapting to physiological conditions, particularly the gradual decrease in heart rate (Oliveira et al., 2023). By performing movements with light intensity, blood supply to the muscles is gradually restored (Hooren, 2018). Active cooling can be performed for specific exercises that require athletes to perform light movements to restore heart rate during training or competition (Afonso et al., 2021). In addition to lowering the heart rate, active cooling exercises also improve the balance of the autonomic nervous system. When the body actively stretches muscles in a controlled manner through movements created in the exercise program, the parasympathetic nervous system is more stimulated, which helps the body normalize the heart rate (Brilian et al., 2021).

The process of lowering the heart rate after physical exercise followed by active cooling exercises involves the sympathetic and parasympathetic nervous systems. During exercise, the sympathetic system is highly active, releasing neurotransmitters such as norepinephrine, which can respond to the heart rate. The sympathetic nerves work through the sinoatrial node and atrioventricular node in the heart, increasing the rate of depolarization and conduction of electrical impulses, thereby increasing heart rate. After exercise ceases and active cooling down is performed, sympathetic nerve activity decreases gradually (Abidin et al., 2021). Active cooling down exercises with movements tailored to the exercise program are highly recommended to facilitate continuous blood flow throughout the body. These active cooling down exercises involve active stretching movements, and an active cooling down session performed during the first 6 minutes after exercise is more effective (Rodríguez-Marroyo et al., 2021).

Active cool down facilitates an increase in parasympathetic nerve activity, which is primarily mediated by the vagus nerve. This nerve is part of the parasympathetic nervous system and releases the neurotransmitter acetylcholine. Acetylcholine acts on the sinus node and the atrioventricular node, reducing the rate of depolarization and slowing the conduction of electrical impulses. Vagus nerve activity increases during active cool-down exercises, causing the heart rate to gradually decrease. The process occurring during active cool-down exercises with continuous body movements helps restore balance between the sympathetic and parasympathetic nervous systems, guiding the body back to a resting state. Active cooling exercises are more effective in the first 6 minutes, as they can lower the heart rate more quickly (Özsu et al., 2018). These results align with the study's objective that active cooling exercises are highly beneficial for athletes who have just finished training.

The Effect of Passive Cooling Exercises on Heart Rate Decrease in Female Volleyball Athletes

Based on the results of research conducted by researchers, the second data shows that there is a significant effect on the decrease in heart rate that occurs when the sample is given passive cooling exercises. Passive cooling exercises, when performed on athletes who have just completed training, result in a less than optimal bodily response (Vegte et al., 2018). Passive cooling exercises are highly suitable for athletes in the recovery phase of training or can be performed after the cooling-down session is completed. Passive cooling exercises can also be applied to athletes undergoing post-injury recovery (Andriana, 2022). Passive cooling exercises still reduce heart rate, but the response is slightly delayed because the athlete stops activity abruptly, causing blood circulation in the body to suddenly become difficult to flow, thereby slowly improving heart rate. However, the athlete moves their body with assistance from others and waits for their body to be assisted during the cooling exercise (Afonso et al., 2021). Research also shows that passive cooling exercises cause the accumulation of metabolic waste in the muscles and slow down the decrease in heart rate (Mukhopadhyay, 2022).

Immediate cessation of exercise can slow down the decrease in heart rate that occurs during exercise or play (Barcala-furelos et al., 2016). When athletes perform passive cooling-down exercises, there is a resting response during each movement, followed by external assistance during the exercise. This can slightly hinder blood flow because it cannot be directly distributed throughout the entire body (Yang et al., 2019). During passive cooling down, parasympathetic activity, particularly through the vagus nerve, begins to increase. However, it is not as effective as during active cooling down because passive cooling down movements are not continuous like active cooling down. Sympathetic system activity increases when exercise begins. After exercise ends and passive cooling down (static stretching) is performed, the parasympathetic system activates and sends signals to the heart to gradually lower the heart rate (Hazır, 2016).

These results are inconsistent with the study's objective that passive cooling down is beneficial for athletes with injuries, undergoing rehabilitation, or in muscle recovery.

The percentage that has been obtained to claim that the data from each cooling treatment has a significant effect, but in this study, the one that has a greater effect is active cooling exercises with a difference between the initial test and the final test of active cooling exercises of 5.70% and for passive cooling exercises of 3.68%. Although active and passive cooling exercises have a comparison that is not too far apart, both exercises can provide significant results in reducing the heart rate of female volleyball athletes. In one training period, the trainer has prepared a lot of training programs that have their own levels of intensity during core training. In the context of training, trainers also need to be wise in choosing cooling exercises to monitor the decrease in heart rate in order to see the physical condition of the athletes they coach themselves (Abou et al., 2024). However, researchers expect all trainers to be more selective in choosing cooling exercises that are aligned with the core training that will be carried out, starting from choosing cooling exercise movements with the same muscle goals during training (Sági et al., 2021). The data obtained is an acute study or it can be said that this study refers to the training conditions that take place in certain training (Calleja-gonzalez et al., 2018). It is certain that the data can be used to see the cardiovascular system and also see the physical condition of athletes through the pulse recorded after the training program is completed.

Differences in the Effects of Active Cooling Down Exercises and Passive Cooling Down Exercises on Heart Rate Decrease in Female Volleyball Athletes

Active cooling exercises have continuous movements that make blood flow continuously when the parasympathetic nervous system works to restore the pulse to normal conditions, which is indicated by the oxygen supply to the muscles being fulfilled because the heart has pumped blood containing oxygen into the muscles. Active cooling exercises provide a better physiological response, one of the advantages of active cooling exercises is that it accelerates the decrease in pulse rate during the first 6 minutes of active cooling which is achieved at a resting pulse rate or returns to normal (Özsu et al., 2018). While passive cooling exercises take a little longer to restore the pulse rate to normal, because the movements in passive cooling have a pause between the movements performed because there must be external encouragement, then this parasympathetic nervous system responds longer, then passive cooling exercise movements are also very suitable for relaxation for psychological recovery, then it can be done for exercises that are intended to increase the components of physical condition, namely flexibility, so this passive cooling exercise is not in line with the context of research which aims to reduce the pulse rate quickly (Apostolopoulos et al., 2018). Both active and passive cooling exercises have very good benefits for physiological functions, especially a decrease in measurable heart rate (Mika et al., 2016). Judging from the results obtained, both exercises can stimulate the parasympathetic nervous system to decrease the heart rate, therefore the decrease that occurs is not too different, unlike if one of the cooling methods that stimulates the parasympathetic nervous system is compared to a cooling method that does not stimulate the parasympathetic nerve. If both have a good effect on decreasing the heart rate, then the two cooling exercises can be combined, for maximum results.

CONCLUSSION

Based on the results of data processing, data analysis, and hypothesis testing, it can be concluded that the study entitled "The Effect of Active and Passive Cooling Exercises on the Decrease in Heart Rate of Female Volleyball Athletes" provides results that female volleyball athletes need effective and efficient cooling exercises to lower their heart rate faster after training, if without doing the correct cooling exercises, there will be a slow decrease in heart rate, where based on the results that have been studied, active cooling exercises are more capable of lowering the heart rate of female volleyball athletes which quickly return to normal conditions than with passive cooling exercises.

This study has limitations, including a relatively small sample size and measurement constraints due to equipment malfunctions during the training session. Therefore, it is recommended that future research involve a larger and more varied sample, extend the training duration, and add other physiological variables to obtain broader evidence and practical recommendations. The implication of these findings is that coaches should prioritize structured active cool-down exercises to optimize cardiovascular recovery and support the physical condition of athletes after training.

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