Active recovery was better than passive recovery to optimizing post-exercise body recovery

By Laily Mita Andriana

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Abstract

One of the efforts to prevent the overreaching condition is by doing a recovery phase after exercise. The quality and quantity of recovery influence the effectiveness of recovery. The effectiveness of recovery can be observed by heart rate and body temperature after recovery. This study aims to compare active recovery and passive recovery after moderate-intensity continuous training on heart rate and body temperature. The research method used is quasi-experimental and uses a two-group pre and post-test design. Based on the Pocock formula, the research subjects used were 40 women aged 24 years to 35 years. The data collected include heart rate and body temperature. The data analysis techniques used were normality test, treatment effect test (paired sample t-test), and difference test (independent samples t-test). The results showed that active recovery was better than passive recovery to optimizing post-exercise heart rate ($p<0.05$). Active recovery was better than passive recovery in optimizing body temperature ($p<0.05$). It was concluded that active recovery after moderate-intensity continuous training was better than passive recovery to optimize post-exercise recovery and prevent overreaching.

Keywords: Active recovery, body temperature, heart rate, moderate-intensity continuous training, passive recovery

INTRODUCTION

Sports activities cause the body to require more energy sources than resting as compensation, the body's physiological will changes (Scartoni et al. 2020). Exercise can increase heart rate so that blood flow to various tissues that transport oxygen and nutrients can be met according to the body's needs (Miller et al. 2020). The increase in heart rate is triggered by sympathetic and parasympathetic activity, which results in venous vasoconstriction (Morales et al. 2019). The continuous high demand for oxygen and nutrients is certainly not proportional to the concentration in the tissue. It can affect the body's tissues, being deprived of oxygen and the inability of blood vessels to maintain constriction, which will release vasodilator substances that cause blood vessels to dilate (Pimenta et al. 2019). Previous studies stated that heart rate and body temperature had a positive correlation when applied in the training zone (Wada, Ito, and Nakagawa 2020). Therefore, heart rate and body temperature are used as indicators of exercise intensity (Pryor et al. 2019).

Optimizing post-exercise recovery is a very important component of the overall sports paradigm (Djaoui et al. 2017). The role of recovery is considered very important to improve exercise results and prevent over-reaching, which leads to over-training. Quality recovery can prevent the negative impact of the exercise that has been done (Martignetti et al. 2020). When a person does a programmed exercise, the body experiences cell and tissue damage. If this damage continues and is not given repair in the form of recovery, it will cause injury to decrease subsequent exercise performance (Doering et al. 2019). Post-exercise recovery is a physiological phenomenon characterized by the body's return to its normal state. One sign of post-exercise recovery of optimal a decrease in heart rate after exercising compared to heart rate before exercising can be maintained for several hours (Brito et al. 2019). The decrease in heart rate after exercise depends on the intensity of the exercise used because of the effect of excess post-exercise oxygen consumption caused after exercise (Boeno et al. 2019).

The previous studies stated that heart rate and body temperature positively correlated when applied in the exercise zone (McLaren et al. 2018). Therefore, heart rate and body temperature are used as indicators of exercise intensity. When entering the training zone, there is an increase in heart rate according to the level of the training zone (Zeller, Abel, and Strueder 2017). The body requires more energy sources than when the body is resting (Katzmarzyk et al. 2020). Based on these conditions, the body performs a form of compensation by physiological changes by increasing the heart rate so that blood flow to various tissues that transport nutrients and oxygen can be met according to the body's needs (Romero, Minson, and Halliwill 2017).

Activation of the sympathetic nerves triggers an increase in heart rate. The increase in the need for oxygen and nutrients is not proportional to the concentration in the tissue. Based on these conditions, the body tissues experience a lack of oxygen, and the inability of blood vessels to maintain constriction will release vasodilator substances that cause blood to dilate (Pimenta et al. 2019). Decreased sympathetic nerve activity can occur when the body enters the recovery phase after exercise (Doering et al. 2019). The recovery phase can reduce signal transduction, which decreases heart rate due to vasodilation mechanisms (Hooren & Peake, 2018).

The higher the training zone level, the more physical maximum performance when exercising. So that the more intensive exercise carried out for a long duration and is not matched by a good recovery can trigger overreaching (Martignetti et al. 2020). Symptoms of the body caused when in condition overreaching include an increase in heart rate after exercise, body temperature after exercise, and muscle fatigue (Hamlin et al. 2019). Someone who does programmed exercise will experience physiological changes in the body followed by fatigue conditions such as delayed onset muscle soreness, which is a form of body adaptation to exercise (Davis, Alabed, and Chico 2020).

The effect caused by fatigue conditions is that it can trigger a decrease in the body's speed of recovery and reduce the level of alertness in the next activity (Meade et al. 2019). A study showed an increase in body temperature and heart rate after being given passive recovery treatment caused by the buildup of lactic acid in the blood. This buildup can appear because the body lacks oxygen to break down glucose in the blood (Zeller et al. 2017). A study showed that any attempt to reduce fatigue is by doing a cooling phase after exercise. Several cooling phases that can be carried out include active and passive recovery methods (Jaya and Sandi 2019). Passive recovery is an effort to recover the body by staying silent after exercising, sitting, and stretching the body statically (Cheikh et al. 2018). While the cooling phase using the active recovery method can slowly lower post-exercise heart rate and body temperature (Stöggl et al. 2018).

Previous research has shown a gradual decrease in heart rate is associated with the withdrawal of the parasympathetic nerves to continue the blood being pumped from the heart to the working muscles and back to the heart during active recovery. Active recovery can prevent lactate accumulation into muscle cells and metabolize as the best recovery method to reduce fatigue and return the body to a normal condition (Hooren & Peake, 2018). The body can reduce blood pressure during passive recovery after activity more quickly (Calleja-González et al. 2019). This happens because recovery from fatigue through static muscle stretching helps the body transition from dynamic body movement to static body movement (Marrier et al. 2017). The subject cooled down by stretching the muscles statically and without controlling the decrease in heart rate in a planned manner, while previously, the research subjects did exercise at an intensity of 80% of the maximum heart rate (Fox et al. 2018). The effectiveness of the recovery is influenced by the quality and quantity of the restoration. The effectiveness of the recovery can be observed in changes in heart rate and body temperature after recovery (Eccles and Kazmier 2019). The right technique of recovery will help optimally restore blood pressure, body temperature, and heart rate to normal conditions (Giudice et al. 2020).

A previous study showed the prevalence of over-reaching in marathon athletes was 7% due to not actively cooling down after exercise (D'Ascenzi et al. 2020). The standing position (without movement or cooling down after exercise) 5-10 minutes after exercise is believed to trigger an increase in venous pressure and blood volume in the legs, on the contrary, there is a decrease in blood flow to the heart and leads to over-reaching. in some cases (D'Ascenzi et al. 2020). Another study comparing active and passive recovery (only standing) after aerobic exercise showed that the prevalence of sudden cardiac arrest occurred in athletes who made passive recovery (Jaya and Sandi 2019). Meanwhile, another study examining heart arrhythmias showed that an athlete who made a passive recovery after aerobic exercise experienced an increase in heart rate that occurred in the 15th minute as a symptom of overreaching (Boeno et al. 2019). Another study showed that the prevalence of post-exercise syncope by athletes after competing was due to inadequate recovery (Hooren and Peake 2018). Based on the description that has been explained, it can be concluded that the cooling down phase after doing a programmed exercise is very important to avoid the occurrence of the overreaching condition. This study compares active and passive recovery after moderate-intensity continuous training on changes in heart rate and body temperature. Compared to previous research, the novelty of this research is that this study compares two types of recovery phases to changes in heart rate and body temperature in the non-athlete community. The advantage of this research is that it shows the trendline of changes in heart rate and body temperature in detail. Measurements were taken from 0 minutes after exercise to 30 minutes after exercise. This research is expected to be an effort to make the public aware of carrying out sports activities in a sustainable, long-term and to carry out quality body recovery strategies so that they can avoid events over-reaching.

METHOD

The method of this study is a two-group pre-test and post-test design. The research subjects will be given active and passive recovery interventions after doing moderate-intensity continuous training. The sampling technique used in this research is simple random. Based on calculations using the Pocock formula, Based on the research results from (Howle, Waterson, and Duffield 2019), the average body temperature before treatment was 39,5, and the average body temperature after treatment was 36,5 and a standard deviation of 3.10. Thus the minimum sample used is as follows;

$$n = \frac{2\,(3{,}10)^2}{(39{,}5 - 36{,}5)^2} \text{ x } 7{,}9$$

From the Pocock formula calculation, the number of samples was 16.8 per group. To avoid some subjects dropping out during the research process, the researcher set a correction factor of 10%, so the replication was 16.7 x 10% = 1.6. Therefore, each group contains a sample of 20 people in the first group and 20 women in the second group. Therefore, this study requires a minimum of 40 women.

Therefore, each group contains a minimum sample size of 20 people. Therefore, this study requires a minimum of 40 research subjects. Research subjects were obtained by broadcasting messages through WhatsApp groups and Facebook and posting pamphlets in public places. People who are interested in becoming research subjects can contact the relevant contact person. The collection of samples is carried out within one month so as to get a sample of 75 people. Samples are declared passed if they meet the inclusion criteria that have been set. The sampling technique used is simple random sampling by inclusion and exclusion criteria. The inclusion criteria were female with a minimum age range of 24 years and a maximum of 35 years. Has no history of hypertension, diabetes, or other metabolic syndrome diseases. The research subject did not follow another research program in the past month. As for the exclusion criteria, is the research subject declared to drop out if he does not follow the intervention a maximum of 1 time.

The research subjects were given treatment in the form of an exercise program for one month with a frequency of three times a week. The exercise program provided is to do moderate-intensity continuous training, namely, aerobic exercise at 88 bpm. The difference in the exercise program between the two groups was in the cooling phase. The exercise duration was 50 minutes, including the first ten minutes of the research subject being in the phase warming up, 30 minutes in the main exercise phase, and 10 minutes in the phase cooling down. The cooling down phase is divided into two types: the phase cooling down using active recovery for group 1 and passive recovery for group 2. In this study, the group given active recovery treatment performed a dynamic recovery. The exercise method is moderate-intensity continuous training by using aerobics to dance to the beat of the song 88bpm. Therefore, the active recovery group was also given an active recovery by using songs using lower beats than during exercise. The song's beat on recovery is 64 bpm which equates to 50% of max heart rate. While the phase, passive recovery, namely cooling by doing movements stretching statically, is a form of recovery from within the body by utilizing muscle movements. The research instruments used were heart rate monitoring and a mercury thermometer. The data analysis techniques used were the mean, standard deviation, normality test (Shapiro Wilk), paired sample t-test, and independent samples t-test.

RESULTS

Table 1. The characteristic of research subject

	Mean & Std. Deviation	
	Active recovery	Passive recovery
Body mass index	24.12 kg/m² ± 2,39	24,31 kg/m² ± 2.29
Maximal heart rate	189 bpm ± 2,77	188 bpm ± 2,72

Based on the data presented in table 1 is data about the research profile of the research subject. The table explains that the average body mass index and maximal heart rate.

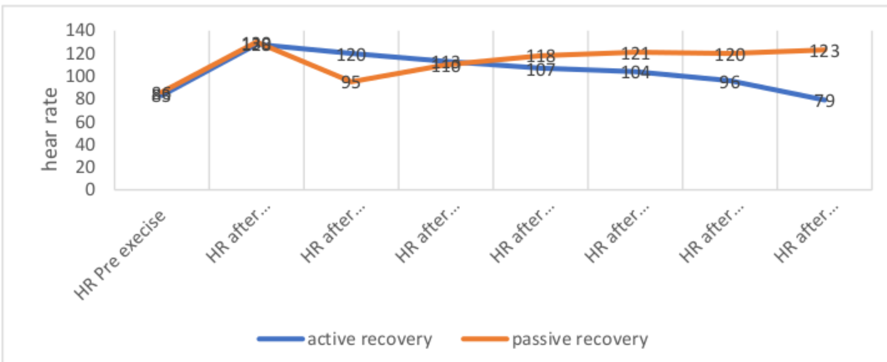

Figure 1. Heart rate after active recovery

Based on the data shown in Figure 1, The heart rate was measured every five minutes. After active recovery, the heart rate decreased steadily. This is evidenced by the data on a decrease in heart rate starting from minute 0, minute 5, minute 10, minute 15, minute 20, minute 25, and minute 30, with a steady decrease in heart rate. Based on Figure 1, it can be explained that the heart rate after carrying out passive recovery changes every five minutes. It is explained that at minute 0 to minute 5, the subject experienced a decrease in heart rate, but at minute 10 to minute 30 the subject experienced a slow increase in heart rate.

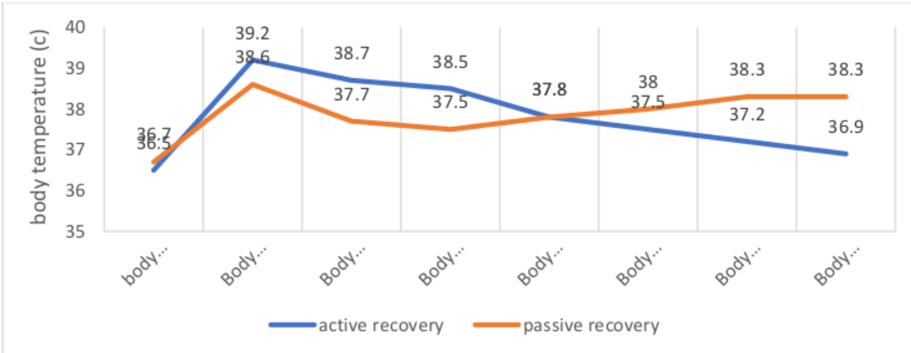

Figure 2. Body temperature after active recovery and passive recovery

Based on the data shown in figure 2, The body temperature has measured every five minutes. The body temperature after active recovery decreased steadily. This is evidenced by the data on a decrease in body temperature starting from minute 0, minute 5, minute 10, minute 15, minute 20, minute 25, and minute 30, with a steady decrease in body temperature. Based on the data, it can be explained that the body temperature after carrying out passive recovery changes every five minutes. It was explained that at minutes 0 to minute 5 and 10 the subject experienced a decrease in body temperature but at minutes 15 to minute 30 the subject experienced increasing body temperature slowly.

Table 2. Paired sample t-test of active recovery and passive recovery on heart rate

Heart rate	Active recovery		Passive recovery	
	Mean difference	p	Mean difference	p
HR 0' – HR 5'	8 Bpm	0,433	35 Bpm	0,000
HR 0' – HR 10'	11 Bpm	0,333	20 Bpm	0,000
HR 0' – HR 15'	14 Bpm	0,000	12 Bpm	0,077
HR 0' – HR 20'	17 Bpm	0,000	9 Bpm	0,544
HR 0' – HR 25'	34 Bpm	0,000	10 Bpm	0,655
HR 0' – HR 30'	44 Bpm	0,000	7 Bpm	0,233
HR Pre exercise – HR 30'	4 Bpm	0,233	37 Bpm	0,000

Based on the data shown in table 2, it is shown that the heart rate of the active recovery group is decreasing slowly. This was indicated by the fact that the group that was given active recovery treatment experienced a decrease in heart rate ($p<0.005$). Based on table 2, it is shown that the heart rate in the passive recovery group experienced an increase in heart rate. This was indicated by the fact that every five minutes, the group given passive recovery treatment experienced an increase in heart rate starting at 15 minutes ($p<0.005$).

Table 3. Independent samples t-test between active recovery and passive recovery on body temperature

Heart rate	Independent sample t-test
	p
HR 0' – HR 5'	0,000
HR 0' – HR 10'	0,000
HR 0' – HR 15'	0,000
HR 0' – HR 20'	0,000
HR 0' – HR 25'	0,000
HR 0' – HR 30'	0,000
HR Pre exercise – HR 30'	0,000

Table 3 describes the difference in heart rate between the active and passive recovery. It was explained that there were differences in changes in recovery heart rate between the two treatment groups of active recovery and passive recovery. The difference between active and passive recovery treatment groups lies in the minute change in heart rate. In the active recovery treatment group, the heart rate decreased steadily. While in the passive recovery group, there was a significant decrease at minute 0 to minute 5 and minute 10, but at minute 15, there was an increase in heart rate. Increased heart rate occurs up to the 20th, 25th, and 30th minutes.

Table 4. Paired sample t-test of active recovery and passive recovery on body temperature

Body temperature	Active recovery		Passive recovery	
	Mean difference	p	Mean difference	p
BT 0' – BT 5'	0,5	0,333	0,9	0,000
BT 0' – BT 10'	0,7	0,233	1,1	0,000
BT 0' – BT 15'	1,4	0,000	0,8	0,000
BT 0' – BT 20'	1,7	0,000	0,6	0,444
BT 0' – BT 25'	1,7	0,000	0,3	0,633
BT 0' – BT 30'	2	0,000	0,3	0,233

BT Pre exercise – BT 30'	0,4	0,433	1,6	0,000

Based on the data shown in table 4, it is shown that the body temperature of active recovery is decreasing slowly. This was indicated by the fact that the active recovery group experienced a decrease in body temperature ($p<0.005$). Based on table 4, it is shown that the body temperature of the passive recovery group experienced an increase in body temperature. This was indicated by the fact that every five minutes, the group given passive recovery treatment experienced an increase in body temperature starting at 15 minutes ($p<0.005$).

Table 5. Independent samples t-test between active recovery and passive recovery on body temperature

Heart rate	Independent sample t-test
	p
BT 0' – BT 5'	0,000
BT 0' – BT 10'	0,000
BT 0' – BT 15'	0,000
BT 0' – BT 20'	0,000
BT 0' – HR 25'	0,000
BT 0' – BT 30'	0,000
BT Pre exercise – BT 30'	0,000

Table 5 describes the difference in body temperature between active and passive recovery. It was explained that there were differences in changes in recovery body temperature between the two treatment groups of active and passive recovery. The difference between active and passive recovery treatment groups lies in the minute change in heart rate. In the active recovery treatment group, the body temperature decreased steadily. While in the passive recovery group, there was a significant decrease at minute 0 to minute 5 and minute 10, but at minute 15, there was an increase in body temperature. Increased body temperature occurs up to the 20th, 25th, and 30th minutes.

DISCUSSION

The results showed that active recovery was better than passive recovery to optimizing post-exercise heart rate ($p<0.05$). Active recovery was better than passive recovery in optimizing body temperature ($p<0.05$). It was concluded that active recovery after moderate-intensity continuous training was better than passive recovery to optimize post-exercise recovery and prevent overreaching. All types of sports activities have different intensities according to the method. One of them is moderate-intensity continuous training or aerobic energy-system sports (Waldron et al. 2021). Someone who does sports activities must pay attention to the intensity of exercise, which can be known through heart rate (McLaren et al. 2018). This research uses the method of exercise moderate-intensity continuous training. One of the sports activities that use the method of moderate-intensity continuous training is aerobic exercise using a beat of 88 beats/minute. The preliminary research that has been done states that aerobic exercise with a beat of 88 beats/minute has an exercise intensity of 80% of the maximum heart rate (Andriana and Ashadi 2019).

When a person exercises and enters the exercise zone, someone automatically needs energy and produces energy dissipation residues that increase body temperature and can increase heart rate (Romero et al. 2017). Previous studies stated that heart rate and body temperature had a positive correlation when applied in the exercise zone (McLaren et al. 2018). Therefore, heart rate and body temperature are used as indicators of exercise intensity (Pryor et al. 2019). When entering the training zone, there is an increase in heart rate according to the level of the training zone (Zeller et al. 2017).

A study states that any attempt to reduce fatigue is by doing a cooling phase after exercise. Several cooling phases that can be carried out include active and passive recovery methods (Morales et al. 2019). Passive recovery is an effort to recover the body by staying silent after exercising, sitting, and stretching the body statically (Jones et al. 2020). While the cooling phase using the active recovery method can slowly lower post-exercise body temperature (Stöggl et al. 2018).

Based on research data that has been carried out, it is stated that the group that was given active recovery treatment experienced a decrease in heart rate and body temperature slowly ($p < 0.05$). In the active recovery treatment group, heart rate and body temperature at 5 minutes after being given treatment did not show a significant decrease in heart rate and body temperature ($p > 0.05$). This condition occurred in the 10th-minute post-treatment ($p > 0.05$) in the 10th-minute post-treatment, there was still a decrease in heart rate and body temperature but not significant. Significant decrease in heart rate and body temperature started at 15, 20, 25, and 30 minutes after active recovery treatment ($p < 0.05$). This is in line with a study that stated that a significant decrease in heart rate and body temperature occurred at 15 minutes after carrying out active recovery (Brito et al. 2019). Based these conditions, it is caused when the body is in an active recovery phase, the body remains in a dynamically moving condition therefore, automatically, the body's metabolic processes are still running, so blood circulation helps accelerate the oxidation process gluconeogenesis in muscles (Schaun et al. 2018). Active recovery aims to prevent a sudden drop in heart rate after exercise (Brito et al. 2019).

Heart rate increases gradually as the intensity of exercise increases to meet the demand for oxygen to active muscles through increased cardiac output (Schaun et al. 2018). The systolic heart rate usually increases by ten ± 2 mmHg per metabolic equivalent increase and can reach a plateau at peak exercise, while the diastolic heart rate changes little or does not change at all (Boeno et al. 2019). Cardiac output increases during exercise because of increased heart rate and stroke volume. After an active recovery, the heart rate is lower than the heart rate before being given treatment, this phenomenon is called post-exercise recovery (Jones et al. 2020).

Post-exercise recovery is a physiological phenomenon characterized by the body's return to its normal state. One of the signs of post-exercise recovery of optimal decrease in heart rate after exercising compared to heart rate before exercising and can be maintained for several hours (Brito et al., 2020). Reduced sympathetic nerve activity causes a decrease in cardiac output and peripheral vascular resistance (Edilma et al. 2017). The gradual decrease in heart rate is related to the withdrawal of the parasympathetic nerves to continue the blood being pumped from the heart to the working muscles and back to the heart during active recovery. Active recovery can prevent lactate accumulation into muscle cells and metabolize as the best recovery method to reduce fatigue and return the body to a normal condition (Hooren & Peake, 2018).

Meanwhile, the heart rate in the passive recovery treatment group experienced a significant decrease in heart rate and body temperature, which occurred 5 minutes after passive recovery treatment ($p<0.05$). During passive recovery, the body can reduce heart rate after activity more quickly (Jones et al., 2019). This happens because recovery from fatigue through static muscle stretching helps the body transition from dynamic body movement to static body movement (Peake et al., 2017). The sudden decrease in heart rate and body temperature 5 minutes after treatment resulted from not setting the heart rate down slowly (Feijen et al. 2020). The subject cooled down by stretching the muscles statically and without controlling the decrease in heart rate in a planned manner. Meanwhile, the research subjects did exercise at an intensity of 80% of the maximum heart rate (Fox et al. 2018).

However, at 10 minutes after passive recovery treatment, there was a gradual increase in heart rate and body temperature ($p<0.05$). The increase in heart rate and body temperature continued at 15, 20, 25, and 30 minutes ($p<0.05$). The increase in heart rate is influenced by the results of vasodilation, namely the condition of widening blood vessels due to low oxygen or increased body temperature (Brito et al., 2019). Research states that when a person is actively exercising and is in the exercise zone, it suddenly slows down, making it difficult for muscle work to flow blood containing carbon dioxide back to the heart (D'Ascenzi et al. 2020). The increase in heart rate that started at 15 minutes after passive recovery treatment was caused by conditions over-reaching so that the body carried out oxygen uptake, which contributed to restoring oxygen stores in the muscles and re-synthesizing adenosine triphosphate and phosphocreatine.

An increase in heart rate is caused by a rise in body temperature and epinephrine levels (Reichel et al. 2020).

The higher the training zone level, the more physical maximum performance when exercising. So that the more intensive exercise that is carried out and carried out for a long duration and is not balanced with good recovery can trigger over-reaching (Martignetti et al. 2020). Symptoms of the body caused when in condition over-reaching include an increase in heart rate, heart rate after exercise, increased body temperature after exercise, increased heart rate, and muscle fatigue (Hamlin et al. 2019). Someone who does programmed exercise will experience physiological changes in the body followed by fatigue conditions such as DOMS (delayed onset muscle soreness), a form of body adaptation to exercise (Davis et al. 2020).

The effect caused by fatigue conditions is that it can trigger a decrease in the body's speed of recovery and reduce the level of alertness in the next activity (Meade et al. 2018). The previous study stated that an increase in body temperature and heart rate after being given passive recovery treatment was caused by lactic acid buildup in the blood (Jafari et al. 2021). This buildup can appear because the body lacks oxygen to break down glucose in the blood (Zeller et al. 2017).

The difference between active and passive recovery treatment ($p<0.05$) lies in changes in the average heart rate and body temperature. Changes in heart rate and body temperature in the active recovery treatment group decreased slowly, shown at minute 0 post-treatment until it continued to minute 30 post-treatment. While the passive recovery treatment-experienced fluctuating changes in heart rate and body temperature. The difference between active recovery and passive recovery treatment lies in modifying the intensity of the exercise performed. In the active recovery phase, the heart rate is conditioned at an intensity of 60% of the maximal heart rate to 50% of the maximum heart rate (Jafari et al. 2021).

Research subjects given active recovery treatment had a slow decrease in heart rate, heart rate, and body temperature (Boeno et al. 2019). While the passive recovery phase, the body is forced to make a quick and sudden recovery (Hooren and Peake 2018). The sudden decrease in heart rate can trigger over-reaching because the body's recovery process does not run optimally (Peake et al. 2017). Therefore, it is highly recommended to carry out active recovery, such as keeping walking after doing sports and performing certain movements so that blood flow can return to the heart slowly and perfusion normally works (Romero et al. 2017).

Exercising in the exercise zone has an effect. Acute pain is in the form of an increase in heart rate, heart rate, and body temperature during exercise caused by sympathetic nerve activation (Kehler and Theou 2019). During exercise, the increase in heart rate, heart rate, and body temperature requires a recovery phase that aims to super compensate for the exercise (Wen et al. 2019). The effectiveness of the recovery is influenced by the quality and quantity of the restoration carried out. The recovery's effectiveness can be observed in changes in heart rate, heart rate, and body temperature after recovery (Eccles and Kazmier 2019). Recovery using the right technique will help optimally restore heart rate, body temperature, and heart rate to normal conditions (Hamlin et al. 2019).

When entering the exercise zone, the body requires more energy sources than when the body is resting (Katzmarzyk et al., 2020). Based on these conditions, the body performs a form of compensation by experiencing physiological changes by increasing the heart rate so that blood flows to various tissues that transport nutrients and oxygen can be met according to the body's needs (Romero et al. 2017). Activation of the sympathetic nerves triggers an increase in heart rate. The increase in the need for oxygen and nutrients is not proportional to the concentration in the tissue. Based on these conditions, the body's tissues are deprived of oxygen and the inability of blood vessels to maintain constriction will release vasodilator substances that cause blood to dilate (Pimenta et al. 2019).

Decreased sympathetic nerve activity can occur when the body enters the recovery phase after exercise (Doering et al. 2019). The recovery phase can decrease signal transduction, which decreases arterial heart rate due to a vasodilation mechanism (Hooren & Peake, 2018).

A study states that inadequate recovery after exercise can be a risk factor for post-exercise syncope, namely loss of consciousness due to inadequate perfusion to the brain, which leads to sudden death. Post-exercise syncope can occur if post-exercise hypotension and loss of muscle contraction in athletes shortly after exercising (Romero et al. 2017). Previous research stated that the prevalence of syncope in marathon athletes was 7% due to not actively cooling down after exercise (D'Ascenzi et al. 2020). The standing position (without moving or cooling down after exercise) 5-10 minutes after exercising is believed to trigger an increase in venous pressure and blood volume in the legs, on the other hand, a decrease in blood flow to the heart causes post-exercise hypotension and leads to events. post-exercisesyncope in some cases (D'Ascenzi et al. 2020). Active recovery can prevent post-exercise syncope and cardiovascular complications. This is because when making an active recovery, muscle contractions still occur so that they can help and facilitate the process of blood flow to the heart and brain. In addition, active recovery prevents blood pooling in the lower extremities and prevents an increase in the partial pressure of carbon dioxide in the arteries (Romero et al. 2017).

A study states that to prevent a sudden decrease in heart rate after exercise, it can be avoided by cooling down to a point where the body is in a normal temperature phase or has reached 50% of the maximum heart rate (Machado et al. 2018). This is also supported by a study that states that the benefits of cooling are to prevent blood pooling and the initial mechanism of post-exercise syncope (Howle et al. 2019). Active recovery has many physiological benefits compared to passive recoveries, such as stable heart rate recovery and recovery, reducing the incidence of post-exercise muscle spasms, and facilitating lactic acid synthesis (Reichel et al. 2020). A study compared active recovery and passive recovery concerning lactic acid levels. The results showed that active recovery was more effective in reducing the concentration of lactic acid ($p<0.05$) (Meade et al. 2019).

The previous study was stated that the average decrease in heart rate occurred at the 15th minute during active recovery. The decrease is due to the effect of prolonged vasodilation on blood vessels. In contrast to the opinion (Romero et al. 2017) which states that a decrease in heart rate occurs at 20 minutes after doing moderate-intensity continuous training. The decrease in heart rate after exercise can be avoided by cooling down to the point where the body is in a normal temperature phase or has reached 50% of the maximum heart rate (Jaya and Sandi 2019).

CONCLUSION

It was concluded that active recovery after moderate-intensity continuous training was better in optimizing recovery and preventing over-reaching than passive recovery. A good recovery must pay attention to the quality and quantity to avoid overreaching events marked by an increase in heart rate and body temperature as a result of an increase in the hormone epinephrine.

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