

# Comparison of Far Infrared Radiation and Warm Water Immersion on Recovery After Submaximal Physical Activity

1<sup>st</sup> Endang Sri Wahjuni  
*Sport Science Faculty*  
*Surabaya State University*  
 Surabaya, Indonesia  
[endangsriwahjuni@unesa.ac.id](mailto:endangsriwahjuni@unesa.ac.id)

2<sup>nd</sup> Arifah Kaharina  
*Sport Science Faculty*  
*Surabaya State University*  
 Surabaya, Indonesia  
[arifahkaharina@unesa.ac.id](mailto:arifahkaharina@unesa.ac.id)

3<sup>rd</sup> Afifan Yulfadinata  
*Sport Science Faculty*  
*Surabaya State University*  
 Surabaya, Indonesia  
[afifanyulfadinata@unesa.ac.id](mailto:afifanyulfadinata@unesa.ac.id)

4<sup>th</sup> Idzam Kholid Akbar  
*Sport Science Fitness Centre*  
*Surabaya State University*  
 Surabaya, Indonesia  
[kholidzam@gmail.com](mailto:kholidzam@gmail.com)

**Abstract**— Recovery is an attempt to make the body recover after physical training. Passive recovery includes Far Infrared Radiation (FIR) and Warm Water Immersion (WWI), but the two recoveries are not well known. The aims of this study were to test the efficacy of FIR, WWI, and Passive (PAS) modalities in decreasing blood lactic acid levels (BLAL) as an indirect marker of muscle fatigue after submaximal intensity physical activity. This is a randomized pretest-posttest control group research. The subject were 21 male students at the UNESA Sports Science Faculty aged 18-23 years. They were assigned three different recovery modalities (FIR, WWI, PAS) in a random order. Subjects were treated with submaximal physical activity (85% maximal heart rate) with ergocycle. BLAL was assessed immediately after physical activity (pre), and after 15 minutes the tested (post). There was a significant decrease in BLAL from the three groups after recovery. The results of different tests ( $p < 0.05$ ) showed a significant difference between  $\Delta$ FIR and  $\Delta$ PAS ( $p=0.006$ ), no differences between  $\Delta$ WWI and  $\Delta$ PAS ( $p=0,082$ ), no differences between  $\Delta$ FIR and  $\Delta$ WWI ( $p=0,692$ ). It can be concluded that the reduction in BLAL was greater in the FIR group than in the WWI and PAS groups.

**Keywords**— *far infrared radiation, warm water immersion, recovery*

## I. INTRODUCTION

Severe physical exercise exposes athletes to physical and mental stress that is important for improved performance, but furthermore it can induce overtraining and even serious injury. This can occur if recovery is inadequate in an exercise program [1]. Recovery is the return of conditions to a baseline state before a match or activity [2]. This phase is a condition that is needed by the body to return to its original state as before the competition. With the return of performance, athletes can improve their physical performance in the next practice or match.

In submaximal activity, 70% of energy comes from the anaerobic glycolysis system and 30% from the aerobic system [2]. This means that in submaximal physical activity with predominant energy from the anaerobic energy system will increase the concentration of lactic acid. Physical activity performed with high intensity and continuously can cause an increase in blood and muscle lactic acid levels [3]. Large increases in lactic acid levels in muscles cause significant

intracellular acidosis. This acidosis causes a decrease in the maximum speed of muscle contraction, which also causes a decrease in muscle power, especially in high-speed contractions. Acidosis can also disrupt the process of power formation because it decreases the speed of glycogenolysis and glycolysis [4]. Blood lactic acid levels exceed 6 mMol/l can disrupt the mechanism of action of muscle cells to the level of coordination movement. This shows that there is an increase in acid levels lactate and recovery is needed [5]. Increased levels of lactic acid will reduce blood pH which causes a decrease in the speed of enzyme reactions in cells so that it will reduce the ability of metabolism and ATP production which is one of the factors causing fatigue. Lactic acid levels in the blood become an indirect marker of fatigue, has a bad influence on the performance of athletes. To reduce fatigue, the lactic acid level must be lowered to the normal threshold again. Recovery will restore energy reserves, removal of lactic acid from the blood and muscles and restore glycogen reserves.

Recovery can be either active or passive (complete rest). The recovery method often used is passive recovery, because the athlete is too tired to add light exercise after a severe exercise. Types of passive recovery include thermal therapy and water immersion.

Thermal therapy is an agent whose only purpose to deliver heat [6]. Thermal Therapy can be done using various methods, including using warm whirlpool, hot packs, warm towels, hot water bottles, ultrasound devices, infrared devices and liquid paraffin tanks [7]. One type of the thermal therapy is infrared (infrared). Infrared radiation is an energy wave that becomes part of the electromagnetic spectrum with the wavelength of 3-100  $\mu$ m and has been used effectively for thousands of years to treat or alleviate certain diseases and discomforts [8]. Infrared classification according to wavelength divided into near infrared, mid infrared, dan far infrared. One infrared device is bag infrared, which is included in the far infrared radiation (FIR) category with a wavelength 5.6-1000  $\mu$ m [1]. FIR wavelengths can penetrate up to 1.5 inches below the skin [8]. The heat from infrared has the potential to improve recovery speed from exercise by improving blood circulation and decreasing the stress of the body [1]. The mechanism effect of FIR radiation is unknown [9], but the same wavelengths between the FIR and the human body can be one

factor that allows for FIR to penetrate deeper into the body [1].

Another type of recovery by water immersion is warm water immersion (WWI). WWI is immersion in water with a range of temperatures where humans do not use energy to stay warm or stay cold. Warm water ranges from  $\geq 20^{\circ}\text{C}$  and  $\leq 36^{\circ}\text{C}$  [10]. Temperature  $31^{\circ}\text{C} - 37^{\circ}\text{C}$  this temperature range considered quite safe and provides a relaxing effect, reduces pain, increases the ability of body motion. This is a positive impact on the heart and lung muscles, circulation breathing becomes better. The temperature of warm water will improve circulation blood and improve the performance of enzymes that work on the body's metabolism in producing ATP. The effect of heat causes dilation of blood vessels and increases blood circulation also tissue oxygenation so as to prevent muscle stiffness. In this study used temperature  $31^{\circ}\text{C} - 35^{\circ}\text{C}$ .

Because the effect of FIR and WWI on muscle fatigue recovery is unclear, it is necessary to investigate the effect on changes in blood lactic acid level (BLAL) after submaximal physical activity. The purpose of this study was to prove the effect of FIR with infrared bag method and WWI to decrease of blood lactic acid level after submaximal physical activity

**II. MATERIALS AND METHODS**

This research is quantitative approach with the pretest-posttest control group design. The protocol in this study was approved by the ethics commission of the Faculty of Dentistry Airlangga University. The population were the second semester students of Sport Science, Faculty of Sport, University of Surabaya, male, 18-23 years old, normal resting heart rate (60-80 bpm), normal BMI (18,5-22,9 kg/m<sup>2</sup>). The sample size was 21 people, divided into three groups with simple random sampling. Consists of the FIR group (n=7), the HWI group (n=7), and the PAS recovery or control passive recovery group by lying down (n=7).

**A. Procedure**

The group 1 (G1) is FIR recovery group with infrared bag method  $45^{\circ}\text{C}$ . The group 2 (G2) is WWI recovery  $33^{\circ}\text{C} - 35^{\circ}\text{C}$ . The group 3 (G3) is passive recovery by lying down in the room  $24^{\circ}\text{C} - 26^{\circ}\text{C}$ . Before physical activity, measurements of blood lactic acid (baseline) were measured. They do some stretching first, then warm up by paddling the ergocycle for 5 minutes with increasing load and speed to limit the subject's capability (85% HRM). After reaching the subject's submaximal ability, it was maintained for 5 minutes. After that the speed was lowered gradually for cooling down for 5 minutes. Preliminary observations of submaximal exercises by measuring BLAL immediately after physical activity as the pretest data. Subjects recovered and retrieved posttest data. Measurement of blood lactic acid level with accutrend lactate analyzer. The G1 recovery used Far Infrared heating element which was made from carbon fiber yarn, provided with  $45^{\circ}\text{C}$  for 15 minutes (Jaco/South Korea/ $45 - 80^{\circ}\text{C} / 500$  watt). The G2 recovery in warm water temperature of  $33^{\circ}\text{C} - 35^{\circ}\text{C}$  is carried out with a total duration of 15 minutes, with 2 minutes immersion in warm water, standing 3-5 seconds then entering again into warm water for 1 minute then standing 3-5 seconds

with repetitions each 5 times. The G3 recovery by lying at room temperature.

**B. Data Analysis Technique**

Data analysis of research result using: (1) descriptive statistical test; (2) Normal distribution test, (4) homogeneity test, and (3) Different test.

**III. RESULT AND DISCUSSION**

Based on measurements on the subject, the following results are obtained:

TABLE I. Mean of Age, Weight, Height, BMI and HR Rest

Variable	G1 (n=7)	G2 (n=7)	G3 (n=7)
Age (year)	19,71 ± 1,70	18,86 ± 0,38	20 ± 1,16
Weight (kg)	60,13 ± 4,16	61 ± 7,02	59,31 ± 5,28
Height (cm)	167 ± 4,76	170,86 ± 8,45	167,86 ± 6,07
BMI (kg/m <sup>2</sup> )	21,54 ± 0,68	20,88 ± 1,80	21,03 ± 1,21
HR rest (bpm)	68,14 ± 7,80	64,32 ± 2,34	63 ± 2,89

Note:  
G1 = FIR group  
G2 = WWI group  
G3 = PAS group

TABLE II. Mean Value of Blood Lactic Acid Level

Group	Pretest (mMol/l)	Posttest (mMol/l)	Δ
G1	10,94 ± 1,03	5,71 ± 0,97*†	-5,23 ± 1,52‡
G2	10,27 ± 0,48	5,90 ± 0,73*†	-4,37 ± 0,74
G3	11,33 ± 0,95	8,61 ± 2,21*	-2,72 ± 1,46

Note:  
\* = significant difference with pretest (p < 0.05)  
† = significant difference with the G3 posttest  
‡ = significant difference with delta G3  
Pretest = immediately after submaximal physical activity  
Posttest = immediately after recovery

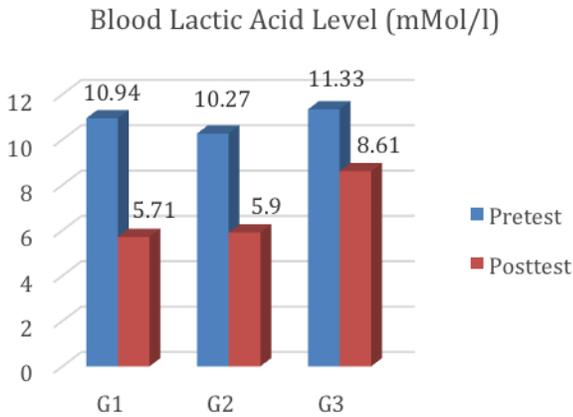


Fig 1. Mean Blood Lactic Acid Level

The research shows an increase in BLAL immediately after physical activity in all groups compared to the baseline condition. This proves that there was an increase in BLAL as a result of anaerobic metabolism after subjects perform submaximal intensity physical activity in all groups. The mean values of BLAL were immediately after recovery in all groups decreased, it showed that there was a decrease in BLAL after the subjects recovered either with FIR, WWI and PAS. The results of measurements showed a significant difference in BLAL posttest G1 with the control group, as well as G2 with the control group. This means that the decrease in BLAL on G1 and G2 was higher than the G3.

TABLE III. Different Tests for Decreasing Blood Lactic Acid Level ( $\Delta$ )

	G1	G2	G3
G1	-	0,692	0,006*
G2	0,692	-	0,082
G3	0,006*	0,082	-

Note:

\* = significant difference ( $p < 0.05$ )

Based on the results of different tests,  $\Delta$ BLAL (pretest-posttest) between G1 and G3 showed a value of  $p=0.006$  ( $p < 0.05$ ). There was a significant difference in decreasing BLAL immediately after physical activity compared immediately after recovery in G1 with G3.  $\Delta$ BLAL in G2 and G3 showed a value of  $p=0.082$  ( $p > 0.05$ ) as well as in G1 and G2  $p=0.692$  ( $p > 0.05$ ). There was no significant difference in the decreasing BLAL immediately after physical activity compared immediately after recovery.

The results of this study prove that the heat from FIR gave an effect on the decrease of BLAL. The heat has potential to improve recovery from exercise by increasing blood circulation and decreasing body stress conditions [1]. The heat from the infrared bag causes vasodilation of the skin blood vessels. It will increase blood flow about twice as much as it

can promote heat loss from the body and cause increased oxygen supply, antibodies, leukocytes, nutrients and enzymes, together with increased metabolite elimination [11]. This acceleration of circulation helps speed up the recovery, due to the acceleration of supply of all the necessary tissue and the acceleration of disposal of metabolites/lactic acid. Resulting in increased expenditure of lactate metabolism from muscle to blood circulation, and acceleration of lactate metabolism by neutralizing organs [4].

According [7], the heat produced by FIR can increase skin blood flow by widening the blood vessels that can increase the supply of oxygen and nutrients in the tissues. Increased oxygen supply is useful to restore the state of oxygen debt and supply nutrients as an energy source, so that oxygen demand was met and the role of aerobic metabolic system becomes dominant. In the presence of oxygen, lactate can be transported into the mitochondria to be oxidized. Lactate can be picked up from cells by MCT, possibly along with extracellular transport from  $H^+$ . Then be taken and used as fuel by adjacent skeletal muscles, as well as the heart, brain, liver and kidneys so that the blood lactic acid level can be decreased [12].

Hauswirth [13] comparing the effects of far infrared (FIR), whole-body cryotherapy (WBC) and passive recovery (PAS) therapy on recovery after intensive walking performance in highly trained runners. The result is FIR can accelerate recovery and maximum strength performance. Nojonen [1] also found an increase in the recovery of anaerobic performance in power athletes when compared to the passive recovery modality. Laturco [14] revealed that FIR administration reduced Delayed Onset Muscle Soreness (DOMS) felt after plyometric training. Some studies state that heat therapy accelerates recovery more than cold therapy or passive recovery by sitting still.

Although there were no significant differences between  $\Delta$ G2 and G3, WWI had a significant effect on the decreased in BLAL after physical activity. There was possible when water immersing the body gets hydrostatic pressure that causes the transfer of fluid in the body from peripheral to heart [15]. There fluid transfer can increase substrate translocation of the muscle, increase cardiac output, reduce peripheral resistance, and increase ability of the body to transport the substrate. In addition, the effect of anti-gravity caused the float force in the water can reduce the perception of fatigue and energy use efficiently and rationally [16].

Putra's research reports that immersing in warm water (temperature  $35^{\circ}C - 37^{\circ}C$ ) after submaximal physical activity active and passive can reduce blood lactic acid levels. Physiologically immersing warm water will cause vasodilation which results blood flow increases, so increased oxygen supply in the blood. Increased oxygen supply will cause decomposition lactic acid becomes pyruvic acid and becomes energy faster.

Warm water give a physiological impact on the body, the blood circulation becomes smooth. Second, factor of loading in the water will strengthen the muscles and ligaments that affect the joints of the body. Third, exercise in the water has a positive effect on the heart muscle and lungs, breathing circulation gets better. The temperature of  $31^{\circ}C$  give effect of the tissue oxygenation, so it can prevent muscle stiffness,

relieve pain and make the body relax. Warm water, can help strengthen the muscles and ligaments and facilitate blood circulation and the respiratory system [10].

Sufficient oxygen supply during recovery, will play a role for metabolic process in the muscles together with pyruvic acid through the Krebs's cycle process [3]. The pyruvate oxidation increases with the catalyst of the pyruvate carboxylase enzyme, so the pyruvate enters to the Krebs cycle. Aerobic metabolism is not produced lactic acid, so that lactic acid levels will decrease. Increased blood circulation is also needed to transport lactate to the liver. Lactate is converted into glucose in the process of gluconeogenesis that takes place in the Cori cycle in liver cells. Thus a larger ATP is formed and the lactate levels decreases to accelerate the recovery of physical fatigue.

#### IV. CONCLUSION

The effect of FIR recovery with bag infrared method and warm water immersion was decreased in BLAL. The reduction in BLAL was greater in the FIR group than in the WWI and PAS group. Researchers suggest that using infrared bags for recovery should require special procedures such as rehydration before radiation, are prohibited from using accessories or clothing made of metal, sufferers of injuries and inflammation are prohibited from doing infrared radiation recovery.

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