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The Effect of Pollen Supplementation on the Recovery of Lactic Acid Levels and Heart Rate After 1 Hour of Submaximal Exercise

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Abstract
This study aims to demonstrate that supplementation with pollen nutritional ingredients can enhance the rate of decrease in lactic acid levels and heart rate after 1 hour of submaximal exercise loading. The research methodology employed is experimental, utilizing a randomized one-group pre-test and post-test design. The sample consisted of 11 students from the Sports Science Study Program at Surabaya State University. Data analysis was conducted using the T-Test with a significance level of 0.05. The findings revealed a decrease in blood lactic acid levels and pulse rate after 1 hour of submaximal exercise. The percentage decrease in pulse rate was 91.541%, while the percentage decrease in blood lactic acid levels was 85.099%. However, it is important to note that comparing the percentage decrease in pulse rate to the percentage decrease in blood lactic acid levels may not be accurate due to the distinct nature of the two systems. Additionally, the supplement group demonstrated greater improvement compared to the control group, which did not receive supplements. Nonetheless, it should be acknowledged that both research variables had not fully returned to pre-exercise conditions.

Keywords: heart rate; lactic acid; pollen; submaximal exercise

1. Introduction

The influence of exercise training on biological function can occur at the system, cellular, molecular, and even electron configuration levels (Mohammad et al., 2021). The recovery phase is a period of returning the body's condition to its state before exercise activity. This phase is a very important state for the body to return to its original state. The recovery phase is a complex process with various durations depending on each biological function type (Gonzalez et al., 2016). So far, the duration of the recovery phase has been used as a reference to determine the degree of fitness, exercise intensity, exercise rhythm, exercise frequency, and competition time (Romero et al., 2017). Excessive load and/or lack of recovery phase will result in symptoms of overtraining syndrome, which affects both physically and psychologically (Quinn, 2007). So far, the usual duration of the recovery phase used as a reference is for the recovery of the cardiovascular system and the energy metabolism system. Recovery of the cardiovascular system function, as indicated by the frequency of pulse rate at the system level, can occur within minutes, while recovery of the energy metabolism system can occur within minutes to hours (for phosphocreatine recovery and lactate elimination), and within days (for glycogen reserve recovery) (Costill et al., 2008).

The acute effect of exercise on changes in pulse frequency is that the pulse frequency increases as the intensity of exercise increases. This increase in resting pulse frequency is due to the fact that during exercise, the need for blood to transport oxygen to active body tissues will increase (Costill et al., 2008). In addition to the acute effects, exercise also causes chronic effects, namely in the form of a decrease in resting pulse frequency. The heart rate or pulse is controlled by the nervous system. In this regulatory system, the response in the form of an increase in nerve impulses from the brainstem to the sympathetic nerves will cause a decrease in the diameter of blood vessels and an increase in heart rate frequency. Changes in heart rate, both increasing and decreasing are regulated by sympathetic and parasympathetic activity (McArdle et al., 2014).

The recovery phase after exercise plays a crucial role in restoring the body's physiological functions. It involves the restoration of various systems, including cardiovascular and energy metabolism systems. Research has shown that exercise training can have significant impacts on these systems at the cellular and molecular levels (Bishop et al., 2020; Safdar et al., 2021). The duration of the recovery phase varies for different biological functions. Studies have highlighted that the recovery of the cardiovascular system, as indicated by pulse rate frequency, can occur within minutes, while the recovery of energy metabolism, such as phosphocreatine and lactate elimination, may take minutes to hours (Forbes et al., 2020; Jentjens & Jeukendrup, 2016). Additionally, the replenishment of glycogen stores, an essential energy source, may require several days (Impey et al., 2018). It is important to consider adequate recovery time to prevent the negative effects of overtraining (Rusdiawan et al., 2020) and optimize performance (Heaney et al., 2021).

Costill, et. al., (2008) stated that short-term, high-intensity activities such as sprinting and fast swimming that rely on the anaerobic energy system produce large amounts of lactic acid and H+ ions in muscles. Following physical exercise, the amount of lactic acid in the blood increases. Therefore, activities that can accelerate the elimination of lactic acid are needed to promote fast recovery (Bzik et al., 1993). The peak accumulation of lactic acid occurs 5 minutes after physical exercise (Gollnick, Philip et al., 1986). The increase in lactic acid levels in the muscle and blood results in a decrease in pH, leading to unfavorable effects on cellular activity due to the disturbance of enzyme performance in metabolic processes. It takes approximately 1 hour of recovery time to eliminate the buildup of lactic acid (Fox, 1993). To restore muscle pH to pre-training conditions, it takes approximately 30-35 minutes of recovery time. (Costill et al., 2008). In treadmill runners, a similar amount of time is needed to reduce their lactate levels. This indicates that it takes approximately 1 hour and 15 minutes after maximal exercise to eliminate 95% of the lactate accumulation (Bzik et al., 1993). In sports that are submaximal but still heavy, the accumulation of lactate is not as significant, resulting in a shorter recovery time.

Pollen functions as a building material, growth promoter, and cell/tissue repairer. Due to its complete nutrient content, pollen is used as a food supplement, reducing fatigue and also increasing vitality. (Suranto, 2007). It contains high levels of vitamins A, B, C, E, as well as inositol (Almeida-Muradian et al., 2005), In addition, pollen also contains a variety of minerals and trace elements that contribute to its health benefits (Baky et al., 2023). These include calcium, magnesium, potassium, zinc, iron, copper, and manganese, among others. These minerals and trace elements are essential for various biological processes in the body, such as bone formation, immune function, and energy metabolism. (Campos et al., 2008). Pollen has been found to have beneficial effects on vitality, cancer, obesity, and lowering triglycerides. (Sarwono, 2001), In addition, pollen is also beneficial for fever and gastroenterology, as an antibacterial, antifungal, antioxidant, and immunomodulatory agent. (Bogdanov, 2014; Campos et al., 2008). Based on empirical experience, taking 2 capsules in the morning provides an effect of reduced fatigue and increased energy throughout the day. Therefore, pollen has great potential as a solution to meet the protein and other nutritional needs of athletes in order to enhance their performance without the use of doping or other potentially harmful compounds (Ali et al., 2021).

Currently, the available products in the market only contain pollen extracts. Therefore, the focus of the planned research is to enrich the bioactive components of pollen by extracting the active components and adding them to fresh pollen, so that with the same dosage, it has a higher bioactive content. This study aims to demonstrate that supplementing with pollen as a nutritional supplement can increase the speed of reducing lactate levels and heart rate after 1 hour of submaximal exercise load.

2. Method

This study employed an experimental research approach utilizing a randomized one-group pre-test and post-test design. The sample consisted of 11 students from the Sports Science Study Program, Faculty of Sports, Surabaya State University. Several criteria were considered when selecting the sample for this study, including being in a healthy condition, non-smokers, non-users of illicit drugs, having an initial pulse rate of 60-80 beats/minute, willingness to participate as research subjects by providing informed consent, and capability to perform sub-maximal exercise (85% HRmax) by pedaling on the Ergocycle. Based on these criteria, a sample of 11 individuals who met the requirements was included in the study.

The instruments, measuring devices, and the composition of the supplement utilized in this study can be provided. Moreover, it is important to verify whether the supplement used has obtained the necessary permits or certificates for consumption.

The data collected from the measurements were processed and analyzed using the SPSS software program, with a significance level of 5%. The statistical tests conducted encompassed descriptive statistical analysis, normality tests, and paired t-tests.

3. Result

Summary of descriptive statistics results is presented in Table 1.

Table 1. The mean and SD values of research

Variable	Mean	SD
Blood lactic acid level (nMol/L)		
Beginning	2,282	0,555
5' after	8,209	1,078
60' after	3,091	0,501
Pulse (beat/min)		
Beginning	73,369	1,180
5' after	135,834	1,628
60' after	84,668	0,969
5' recovery		
Blood lactic acid level	28,275	0,105
Pulse	26,971	0,298
60' recovery		
Blood lactic acid level	85,099	11,515
Pulse	91,541	83,361

The result of the normality test is presented in table 2

Tabel 2. The results of the normality test

	Blood lactate levels				Pulse		Recovery Persentage 5'		Recovery Persentage 60'	
	(mMol /L)	(beat/ menit)	(%)	(%)	(mMol /L)	(beat/ menit)	(%)	(%)	(mMol/ L)	(beat/m enit)
Mean ± SD	2,282 ± 0,555	8,209 ± 1,078	3,091 ± 0,501	73,369 ± 1,180	135,834 ± 1,628	84,668 ± 0,969	28,275 ± 0,105	26,971 ± 0,298	85,099 ± 11,515	91,541 ± 83,361
P	0,549	0,805	0,444	0,589	0,634	0,937	0, 537	0, 689	0,971	0,832

Based on table 2, it is obtained that the p-value > 0.05. This means that all data on the research variables are normally distributed.

And from the above analysis, the percentage of changes in the research variables is shown in Figure 2 below:

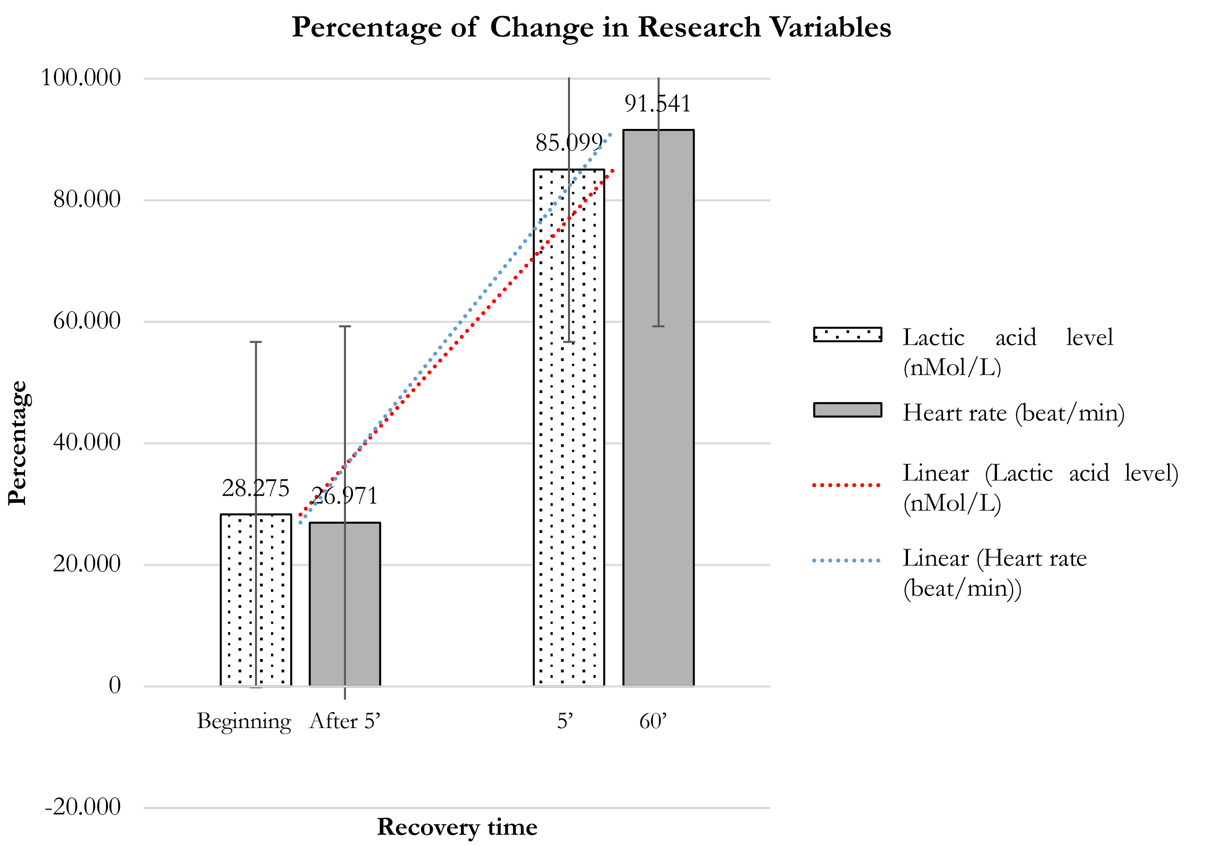

Figure 1. Percentage of Change in Research Variables

From the graph above, it is found that the average change in pulse rate is greater than the average change in blood lactic acid levels at 60 minutes after exercise.

The Paired T-test was used to analyze the percentage reduction in blood lactic acid levels with a pulse rate of 60 minutes after submaximal exercise using a significance level of 0.05. The results of the analysis can be seen in table 3.

Table 3. Results of the Paired T-test of Research Variables

Variable	Mean and SD (%)	p
Decrease in blood lactic acid levels	85,099 ± 11,515	0,012
Decrease in pulse rate	91,541 ± 83,361	

Based on the table above, it was observed that comparing lactate levels and heart rate may not be appropriate due to the differences in the two systems. It may be more suitable to analyze the measurements at individual time points, such as baseline, 5 minutes after, and 60 minutes after submaximal exercise. Furthermore, considering the specific time intervals would provide a more accurate assessment of the effect of pollen supplementation on the decrease in pulse rate and blood lactic acid levels.

The results of the percentage incidence of decreased blood lactic acid levels and pulse rate of the study subjects are listed in the following table:

Table 4. Percentage of the incidence of decreased blood lactic acid levels, pulse rate of research subjects

Range	Blood Lactic Acid	Pulse
% decrease	Amount	Amount
0-15	0 (0 %)	3 (27,27 %)
16-30	0 (0 %)	1 (9,09 %)
31-45	0 (0 %)	1(9,09 %)
46-60	0 (0 %)	2 (18,18 %)
61-75	2 (18,18 %)	2(18,18 %)
76-90	6 (54,54 %)	2 (18,18 %)
91-100	3 (27,27 %)	0
Total	11	11

From table 4 above, it is obtained that the percentage calculation of the incidence for the decrease in blood lactic acid levels is the most in the range of 76-90%, which is as much as 54.54%. This means that only the number of samples experienced a relatively lower decline and the average percentage of decline was 85,099% in this range.

In addition, from table 4 above, it is obtained from the calculation of the percentage of occurrence rates for the most decrease in pulse rate is in the range of 0-15%, namely as much as 27.27%. This means that only the number of samples experienced a relatively small decrease or almost no decrease in pulse rate. Within 1 hour after submaximal exercise the percentage of decreased pulse rate has not fully returned to the pre-exercise pulse rate. It takes longer to clear the pulse from the body after exercise. The higher the pulse, the slower the ability to return to the starting position. 1 hour rest is not enough to restore the pulse at the start before exercise (Gustian et al., 2022).

4. Discussion

The discussion revolves around examining the effect of pollen supplementation on the obtained results. To enrich the discussion, relevant and up-to-date scholarly resources from the library have been incorporated.

Giving pollen causes a decrease in blood lactic acid levels and pulse rate 1 hour after submaximal exercise. This is because pollen contains more than 250 biologically active substances, including proteins, carbohydrates, lipids, fatty acids, vitamins, minerals, enzymes, and antioxidants. Pollen is also loaded with various kinds of antioxidants, such as flavonoids, carotenoids, quercetin, kaempferol, and glutathione (Rizal, 2020). Notably, pollen is abundant in various antioxidants such as flavonoids, carotenoids, quercetin, kaempferol, and glutathione.

To determine the percentage decrease in blood lactic acid levels and pulse rate, the difference between the values measured 5 minutes after submaximal exercise and those measured 1 hour after submaximal exercise was calculated. This difference was then divided by the initial difference between the values measured 5 minutes after submaximal exercise and the values obtained before submaximal exercise, multiplied by 100%. The research findings revealed an average percentage decrease in blood lactic acid levels of 85.099% and an average percentage decrease in pulse rate of 76.774%. Statistical analysis using the paired t-test yielded a significant p-value of 0.012 ($p < 0.05$).

These results suggest that the percentage decrease in heart rate is smaller than the percentage decrease in blood lactic acid levels 1 hour after submaximal exercise. Pulse rate serves as an indicator for monitoring overall health, with consideration given to the accuracy of the pulse before and after exercise (Gemael & Febi, 2020). However, it is important to note that within 1 hour after submaximal exercise, the percentage decrease in pulse rate had not fully returned to the pre-exercise levels.

Based on the results, the study demonstrates that pollen supplementation leads to a decrease in blood lactic acid levels and pulse rate 1 hour after submaximal exercise. To enrich the discussion further, additional relevant and up-to-date library resources have been incorporated to support and expand upon the findings.

5. Conclusion and Recommendations

Based on the research findings, it can be concluded that submaximal exercise leads to an increase in blood lactate levels and heart rate after 5 minutes. However, the administration of pollen supplements resulted in a decrease in both blood lactate levels and heart rate after 1 hour of submaximal exercise. The percentage decrease in heart rate was 91.541%, while the percentage decrease in blood lactate levels was 85.099%. These results indicate a greater reduction in heart rate compared to blood lactate levels after 1 hour of exercise. Nonetheless, it is important to note that neither variable fully returned to pre-exercise levels within the timeframe of the study.

Based on these findings, it is recommended to further explore the effects of pollen supplementation on longer recovery periods and examine its potential benefits for overall exercise performance and endurance. Additionally, additional research is needed to investigate the optimal dosage and duration of pollen supplementation for maximizing its impact on reducing blood lactate levels and promoting recovery.

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