

The Effectiveness of Ginger-Infused Water on Aerobic Endurance: A Randomized Control Trial La eficacia del agua con jengibre sobre la resistencia aeróbica: un ensayo de control aleatorio

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Abstract. The research aims to see the effectiveness of infused water in influencing aerobic endurance. The research used a controlled experimental method with a pretest-posttest design. According to the criteria, fifteen participants were divided into three groups using purposive sampling. The control group (CT), and experimental group one (EKO) were given infused water with a combination of red ginger, lemon, and mint leaves, and experimental group two (EKT) were given infused water with variations of *empit* ginger and lemon and mint leaves. The beep test is used to assess aerobic endurance. Pre-tests and post-tests were given before and after treatment. Data analysis used a paired t-test, followed by one-way ANOVA statistical analysis with SPSS-25. The results showed that there was a difference in pre-test and post-test aerobic endurance in the EKO group with a sig value of $0.011 < \alpha = 0.05$, but there was no difference in pre-test and post-test aerobic endurance in the EKT group with a sig value of $0.052 > \alpha = 0.05$. If the post-test results of the experimental group are compared with the control group, a significance value (p-value) = $0.804 > \alpha = 0.05$ is obtained. It was concluded that giving red ginger water infusion could significantly increase aerobic endurance before and after treatment. Meanwhile, when giving *empit* ginger-infused water, there was no significant difference in aerobic endurance before and after treatment. Compared with the control group, there was no significant difference in aerobic endurance between the control and experimental groups.

Keywords: Effectiveness, Ginger, Infused Water, Aerobic Endurance.

Resumen. La investigación tiene como objetivo ver la eficacia del agua en infusión para influir en la resistencia aeróbica. La investigación utilizó un método experimental controlado con un diseño pretest-postest. 15 participantes según los criterios se dividieron en 3 grupos utilizando una técnica de muestreo intencional. El grupo de control (CT) y el grupo experimental uno (EKO) recibieron agua en infusión con una combinación de jengibre rojo, limón y hojas de menta, y el grupo experimental dos (EKT) recibió agua en infusión con variaciones de jengibre y limón *empit* y hojas de menta. La prueba de pitidos se utiliza para evaluar la resistencia aeróbica. Se realizaron pruebas previas y posteriores antes y después del tratamiento. El análisis de los datos utilizó una prueba t pareada, seguida de un análisis estadístico ANOVA unidireccional con la ayuda de SPSS-25. Los resultados mostraron que hubo una diferencia en la resistencia aeróbica antes y después de la prueba en el grupo EKO con un valor sig de $0,011 < \alpha = 0,05$, pero no hubo diferencias en la resistencia aeróbica antes y después de la prueba en el grupo EKT con un valor sig de $0,052 > \alpha = 0,05$. Si se comparan los resultados post-test del grupo experimental con los del grupo control, se obtiene un valor de significancia (valor p) = $0,804 > \alpha = 0,05$. Se concluyó que dar infusión de agua de jengibre rojo podría aumentar significativamente la resistencia aeróbica antes y después del tratamiento. Mientras tanto, al administrar agua con infusión de jengibre *Emprit*, no hubo diferencias significativas en la resistencia aeróbica antes y después del tratamiento. En comparación con el grupo de control, no hubo diferencias significativas en la resistencia aeróbica entre los grupos de control y experimental.

Palabras clave: Jengibre, Agua Infusionada, Resistencia Aeróbica.

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Introduction

Endurance refers to a person's capacity to work at a high level for an extended amount of time without becoming exhausted (Sepriani, 2017; Sepriani et al., 2018). If a person can constantly work for a long period, he or she is considered to have endurance. Aerobic endurance refers to the ability of large muscles to do moderate-intensity tasks for an extended period (Sepriani & Kurnia Rahman, 2019; Wenly et al., 2021). VO₂ max, which is defined as the highest rate of oxygen consumption achieved during maximal or complete exercise, is a common indicator of aerobic endurance (van der Fels et al., 2020). VO₂ max is the best indicator of aerobic endurance, which is used as a parameter of physical fitness (Syampurma et al., 2021). However, the training ability also depends on submaximal intensities related to the VO₂max percentile applied to exercise (Nunes et al., 2019). Physical conditioning is the most fundamental aspect of any sport,

and it is essential for the development of technical, tactical, and mental skills (dos Santos et al., 2019; Sepriani et al., 2021). Physical conditioning can be done by utilizing elements in the surrounding environment (Guijarro-Romero et al., 2024). Aerobic endurance is a factor in physical conditioning that has assumed an essential role in maintaining of physical function (Lima et al., 2021). In addition to other aspects of physical conditioning, endurance is one factor that affects an athlete's condition (Rodríguez-Fernández et al., 2019). When exercising or engaging in physical activity, the body requires a large amount of oxygen, which is used in the energy formation process (Sinulingga et al., 2022). Infused water is made up of a variety of fruits, spices, or vegetables that have been dissolved in cold water (Ali et al., 2016; Ivak & Rehena, 2019). Infused water drinks are starting to be known and consumed by Indonesians because the making process is easy, and the ingredients are widely available (Sakdiah et al., 2022).

There are two types of ingredients used in the making

of infused water, namely spices and fruit. Sometimes additional ingredients are also added (Agustina & Rahmani, 2021). Variations in ingredients affect the quality of infused water because each ingredient contains different elements. These elements will later be extracted, especially compounds that are water-soluble during the soaking process (Sakdiah et al., 2022). Infused water is prepared by dissolving items in water for at least 2 hours in the refrigerator, allowing the vitamins and minerals in the ingredients to release and causing diverse flavors (Surati & Qomariah, 2017).

Ginger is one of the most commonly used components in the production of infused water (Pebiningrum & Kusnadi, 2018; Pramono, 2020). Ginger is a widely available herb that includes antioxidants as well as vitamin E. Ginger contains active ingredients such as *gingerol*, *shogaol*, *paradol*, and *zingiberone* which contribute to its anti-inflammatory properties (Anugrah et al., 2024; Fathona, 2011; Heru Agus Cahyanto, 2022; Mahmudati et al., 2020). (Wahyuningsih et al., 2018) found that red ginger-infused water has the antioxidant activity of 88.26% RSA DPPH and a FRAP rate of 92.83%; vitamin C content of 158.69 mg/100 g; acidity degree of 2.90; total phenol of 40.22 mg gallic acid/100 ml; (Wahyuningsih et al., 2018).

Based on previous research by Rika and Deswandi, red ginger-infused water has the highest antioxidant activity, at 89%, compared to *emprit* ginger and elephant ginger. Among the three ginger variants, *emprit* ginger has the highest vitamin C content at 72.44 ppm (Sepriani & Deswandi, 2021). Antioxidants can be used to neutralize free radicals that enter the body, thereby preventing oxidative processes that can cause damage to cells. Athletes require these antioxidant compounds to enhance their performance because intense physical activity induces the formation of free radicals that impair their performance. Ginger-infused water will serve as an alternative source of natural nutrition for athletes seeking to enhance their performance, allowing them to avoid the use of substances that can be subsequently identified as doping.

Therefore, this research was conducted to see how infused water affected aerobic endurance. Ginger, lemon, and mint leaves were used to make the infusion water. Red ginger and *emprit* ginger (*Zingiber officinale* Var. *Amarum*) were the varieties of ginger used in this study. From this research, it is expected that in the future, a drink formulation from natural ingredients can be used to improve performance in sports.

Methods

This study is a controlled experimental study with a pre-test-posttest design. This research design was chosen to see the effect of ginger-infused water on aerobic endurance. Experimental group one is given infused water with a combination of red ginger (*Alpinia purpurata*), lemon, and mint leaves, and experimental group two given infused water with a combination of *emprit* ginger (*Zingiber officinale* Var. *Amarum*), lemon, and mint leaves. Meanwhile, the control

group does not consume infused water.

The research sample was taken using the purposive sampling technique by meeting the inclusion criteria, namely: 1) male, 2) between the ages of 20 and 23, 3) in good health with a normal body mass index (BMI), 4) non-smoker 5) do not use any vitamins, antioxidants, or other supplements, 6) agree to participate in the research with Informed Consent (IC). The 15 participants in this study were split into three groups: 1) the control group (CL) that was not given any treatment, 2) group experiment 1 (EKO) that was given red ginger (*Alpinia purpurata*), lemon, and mint infused water, and 3) the group experiment 2 (EKT) that was given infused water containing *emprit* ginger (*Zingiber officinale* Var. *Amarum*), lemon, and mint leaves. According to Idrus Alwi (2012), experimental research can use a relatively small minimum sample size of 3-5 units of observation in each cell or group (Alwi, 2012). According to WHO (2000), each experimental group should have at least five experimental samples.

The procedure used in this research can be described as follows:

- The researcher explained the research procedures to the respondent.
- The researcher divided the respondents into the control group (CL), experimental group 1 (EKO), and experimental group 2 (EKT).
- The CL group received no treatment, the EKO group and EKT group received 14 days of treatment.
- The researcher prepared ginger-infused water with lemon and mint leaves and were put into a clean container with a lid. Add mineral water at 37-40°C to 200 ml and let it sit until it reaches room temperature (25°C). The infused water was stored in the refrigerator (+8.5°C) and allowed to sit for 12 hours (Sepriani & Deswandi, 2021).
- Before administering treatment, aerobic endurance was measured in each sample group using the beep test. According to Heildenberg et al. (Dimarucot & Macapagal, 2021), the beep test can be used to measure VO_{2max} , an indicator of an individual's aerobic endurance. The present study utilized the beep test with a validity of 0.77 (face validity) and a reliability of 0.98 (Doewes & Furqon, 1999).
- The beep test consisted of running 20 meters back and forth at a pace of 8.5 km/h, which increased by 0.5 km/h (Voss & Sandercock, 2009). At the end of each level and for every 20 meters traveled, a "beep" sound will be audible once. If the participant has crossed the boundary line without hearing the warning signal, he or she must wait for the beep before returning. Suppose a sound signal indicates the participant has not yet reached the boundary line. In that case, they must accelerate until the boundary line is crossed and promptly run in the opposite direction. If a participant fails to follow the rhythm of running time twice in succession, it indicates that their maximum ability is limited to that level (one time running back and forth). VO_{2max} predictive value

is derived by matching the beep test norm's level and feedback (Sepdanius et al., 2019).

- g. The obtained VO₂max value data was analyzed using statistical analysis.

The obtained VO₂max data for the experimental group were analyzed using the paired sample t-test in SPSS version 25. Before conducting the analysis, the data's normality and homogeneity were examined as part of a test of the analysis requirements. Then, the experimental groups' VO₂max post-test results were compared with the control group's, using a one-way ANOVA to examine the differences between the three groups.

Result

Research Data Description

The description of research data aims to evaluate aerobic endurance before and after being given treatment. Data description of the results of this study can be seen in table 1.

Table 1.
Research Data Description

Group	Test	Mean	St.Dev	Average Difference of pretest-post-test
Control (CT)	Pre-test	35.04 ml/kg.min	1.89	0.12 ml/kg.min
	Post-test	35.16 ml/kg.s,	1.52	
Experiment 1 (EKO)	Pre-test	34.8 ml/kg.min	4.17	5.98 ml/kg.min
	Post-test	40.78 ml/kg.min	2.53	
Experiment 2 (EKT)	Pre-test	35.58 ml/kg.min	1.94	3.94 ml/kg.min
	Post-test	39.52 ml/kg.min	2.88	

Table 1 displays the difference between the average aerobic endurance values of each experimental group, with the experimental groups demonstrating a greater average increase in aerobic endurance than the control group. Figure 1 below provides further information.

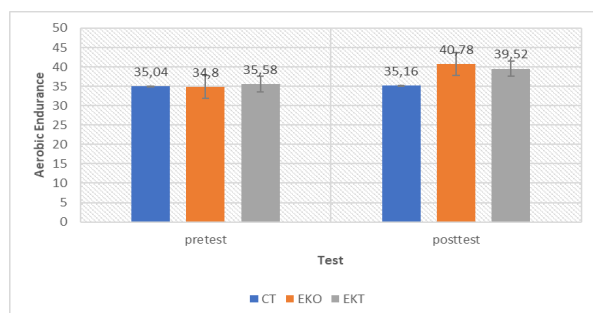


Figure 1. Description of Aerobic Endurance

From the figure 1 above, it can be concluded that there was an average increase in aerobic endurance of 0.12 ml/kg. min. In the EKO group, aerobic endurance increased by an average of 5.98 ml/kg, whereas in the EKT group, aerobic endurance increased by an average of 3.94 ml/kg. min.

Data Normality Test

The Shapiro-Wilk test was used to determine the normality of the data. The Shapiro-Wilk test will be explained in table 2 below.

Table 2.

Normality of research data

Group	Test	α	p-value*
EKO	Pre-test	0,05	0.408
	Post-test		0.644
EKT	Pre-test	0,05	0.873
	Post-test		0.463

*note: p value > 0,05 data is normally distributed

Data Homogeneity Test

The variance homogeneity test is carried out to determine whether the sample group has the same or homogeneous variance (Ghozali, 2018). This test analysis was carried out using the Levene test and is described in table 3 below.

Table 3.

Homogeneity of Research Data

Group	α	p-value*
EKO	0,05	0.251
EKT		0.446

*note: p value > 0,05 data is homogenous

Hypothesis Testing

After verifying the data analysis requirements, data analysis continued with hypothesis testing using the Paired Sample T-test. The data is described in table 4 below.

Table 4.

Paired sample t-test for experimental groups

Group	α	*p-value
EKO	0.05	0.011
EKT		0.052

*note: p value < 0,05 data is a significant difference between pre-test and post-test

Testing continued with one-way ANOVA. Before carrying out the one-way ANOVA analysis test, the assumptions of normality and homogeneity of the data were first tested. The data is described in table 5 below.

Table 5.

Post-test Normality Test in each Test group

Group	α	p-value*
CT	0.05	0.966
EKO		0.644
EKT		0.463

*note: p value > 0,05 data is normally distributed

In addition, the assumption of data homogeneity was tested using Levene test. The data is described in table 6 below.

Table 6.

Post-test Homogeneity Test on Each Test Group

	Levene Statistic	df1	df2	Sig.
Vo2max Based on Mean	.793	1	8	.399

*note: p value > 0,05 data is homogenous

Because the assumptions of the one-way ANOVA statistical test are met, hypothesis testing is continued with the one-way ANOVA statistical test. If the significance value (p-value) is <0.05, then each group differs in aerobic endurance.

The data is detailed in table 7 below.

Table 7.
One-way ANOVA Test Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.036	1	.036	.066	.804
Within Groups	4.384	8	.548		
Total	4.420	9			

Based on the one-way ANOVA statistical test, there is no significant difference in aerobic endurance between the control group (CT), experimental 1 (EKO), and experimental 2 (EKT) after treatment.

Discussion

Excessive fatigue renders a person incapable of doing his or her duties. Fatigue is considered as the momentary inability to generate force (Hernández-Cruz et al., 2022). People are deemed to have endurance in general if they are still able to work continuously for a long period (Bizjak et al., 2020; Engberg et al., 2017). Aerobic endurance refers to the ability of large muscles to do moderate-intensity tasks for a long period. A decrease in haemoglobin levels due to diminished oxygen binding is one of the causes of decreased aerobic endurance (Steiner et al., 2019; Wehrlin & Steiner, 2021). Fatigue can also occur due to decreased aerobic endurance (Hulme et al., 2018; Sepriani et al., 2018).

Oxygen (O₂) is a gas that is essential for metabolic functions (Octavia et al., 2018). Cells require oxygen to turn glucose into energy for various functions, including physical activity, food absorption, immunity, bodily condition restoration, and the destruction of metabolic waste pollutants. The body will require much oxygen during exercise or physical activity, which is required for energy generation (Andari et al., 2021; Steiner et al., 2019). Physical activity refers to all those actions carried out during daily life that could imply energy consumption, through the movement produced by skeletal muscles, above resting values (Victoria et al., 2024). Hypoxia or a lack of oxygen can occur in persons who engage in strenuous or maximum activities, such as athletes, at certain times. In this condition, the partial pressure of oxygen in the blood will decrease, and conversely, the partial pressure of CO₂ will increase. This situation will impact the lack of oxygen gas supply into the cells to produce energy, thereby inhibiting the process of cell metabolism (Astuti et al., 2019; Sepriadi et al., 2020). These abnormalities will be linked to the onset of numerous disease symptoms in the body, including dizziness, shortness of breath, fatigue, muscle and joint pain, nausea, lack of energy, memory loss, a weakened immune system, and even severe degenerative diseases, such as cancer (Sepriani, 2017).

Infused water is a drink that is made by diffusing high-concentration fruit or herbs (high concentration) into water (low concentration). Red ginger and *empurit* ginger-infused water were utilized in this study. This study involved three sample groups: the control group (CT), the first experimental group (EKO), and the second experimental group (EKT).

Before testing the hypothesis, the assumption test was first carried out. Table 5 shows the data are normally distributed. Then, the test for data homogeneity is shown in Table 6. It can be concluded that the data is homogenous.

Since the assumption test was fulfilled, the research hypothesis test was then conducted to determine the effect of infused water on aerobic endurance in each experimental group. From the results obtained in the EKO group, the significance value (p-value) was 0.011 < 0.05. Therefore, it can be concluded that there is a significant difference in aerobic endurance before and after the experiment. While aerobic endurance in EKT, the results of the significance value (p-value) 0.052 > 0.05, and it can be concluded that there is no significant difference in aerobic endurance before and after the experiment. If the experimental groups' post-test value of aerobic endurance is compared with the control group, the significance value (p-value) = 0.804 > α = 0.05, which means there is no difference in aerobic endurance for each test group.

According to Rika (2021), red ginger-infused water with a mix of lemon and mint leaves has 89% RSA DPPH antioxidant activity, whereas *empurit* ginger with the same combination has 86% RSA DPPH antioxidant activity (Sepriani & Deswandi, 2021). Wahyuningsih et al. (2018) did the same experiment, finding that red ginger-infused water had an antioxidant activity of 88.26% RSA DPPH (Wahyuningsih et al., 2018). According to an earlier study, compared to *empurit* ginger, red ginger-infused water has better antioxidant activity. The content of essential oils and solubility determines the number of antioxidants (Kikuzaki & Nakatani, 1993). The difference in antioxidant content of certain compounds affects the oxygen levels in a person's body.

Antioxidants are compounds that can prevent the formation of free radicals in the body (Clarkson, P. M. dan Thompson, 2000; Silalahi, 2006; Zach, 2022). Free radicals can be found in the body due to the oxidation and burning of cells that occurs during respiration, cell metabolism, exercise, or high-intensity physical activity. Athletes frequently engage in excessive or maximal physical activity (Shalaby et al., 2021; Souissi et al., 2020). Athletes conduct programmatic exercises at a high intensity that exceeds their maximum load to achieve the best results (Bompa & Buzzichelli, 2019). Free radicals in the body can inhibit the occurrence of energy metabolism so that a person can't carry out activities (Kuswahyudi; et al., 2022; Sun & Sun, 2017). Infused water with high antioxidant components will aid in preventing free radical formation in the body, allowing for a faster energy consumption rate. Athletes who engage in physical exercise will undoubtedly require a lot of energy formation. Red ginger-infused water enhances aerobic endurance during physical activity more than *empurit* ginger because it has stronger antioxidant activity. However, if we compare each experimental group with the control group, there is no significant difference in aerobic endurance between the three.

Conclusion

Red ginger-infused water combined with lemon and mint leaves is more effective in increasing aerobic endurance based on research. In contrast, the infused water of *empurit* ginger with the same mixture and the control group that received no treatment, did not show a significant difference before and after treatment. However, compared to aerobic endurance in each test, there is no difference between the three. For this reason, red ginger-infused water combined with lemon and mint leaves can be recommended as a natural sports drink option to increase aerobic endurance.

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