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THE EFFECT OF RECOVERY METHODS AND POST-EXERCISE REHYDRATION FLUIDS ON HEART RATE AND BLOOD PRESSURE

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Abstract

*The purpose of this study was to analyze the effects of various recovery methods and rehydration on heart rate and blood pressure. The 24 athletes (age 24,3±5,1 years, 67,6±16 kg, 166,5±5,2 cm, and VO2max 40,6±2,25 ml/kg/min) divided into six treatment groups, namely K1 (passive recovery), K2 (active recovery), K3 (isotonic fluids), K4 (green coconut water), K5 (active recovery+isotonic fluids), and K6 (active recovery+green coconut water). All subjects underwent a fatigue protocol using the Yoyo intermittent recovery test level 1 (YYIRT1), blood pressure and heart rate were measured pre and post the recovery intervention to assess the effects of various types of treatment. The results of this study indicate that active recovery, passive recovery, rehydration fluid administration, and their combination did not reduce systolic blood pressure (p>0.05). However, there was a significant difference in the reduction of diastolic blood pressure (p=0.045). The recovery method using isotonic fluids (K3) showed the highest reduction in diastolic pressure compared to the other treatments. The results of the difference test analysis show a significant difference in heart rate after treatment in each group (p=0.013). Similar results were also found for the difference value between treatments (p=0.004)**.** This study show that the recovery method using isotonic fluids showed the highest reduction in diastolic pressure and heart rate after high intensity exercise compared to the other treatments. Active recovery method after exercise showed most significant decrease in heart rate after exercise.*

Keywords: *recovery methods, isotonic fluid, coconut water, active recovery,*

EFEK PEMBERIAN METODE PEMULIHAN DAN CAIRAN REHIDRASI PASCA OLAHRAGA TERHADAP DENYUT NADI DAN TEKANAN DARAH

Abstrak

Tujuan penelitian ini adalah untuk menganalisis pengaruh berbagai metode pemulihan dan rehidrasi terhadap denyut jantung dan tekanan darah pasca latihan. Sebanyak 24 atlet berbagai cabang olahraga (usia 24,3±5,1 tahun, 67,6±16 kg, 166,5±5,2 cm, dan VO2max 40,6±2,25 ml/kg/menit) dibagi menjadi enam kelompok perlakuan dengan masing-masing 4 sampel, yaitu: K1 (pemulihan pasif/kontrol), K2 (pemulihan aktif), K3 (cairan isotonic komersial), K4 (air kelapa hijau), K5 (pemulihan aktif + cairan isotonic komersial), dan K6 (pemulihan aktif + air kelapa hijau). Semua sampel menjalani protokol kelelahan menggunakan *Yoyo intermittent recovery test level* 1 (YYIRT1), tekanan darah, denyut nadi dan RPE diukur sebelum dan sesudah intervensi pemulihan untuk menilai efek dari berbagai jenis perlakuan. Hasil penelitian ini menunjukkan bahwa pemulihan aktif, pemulihan pasif, pemberian cairan rehidrasi, dan kombinasinya tidak signifikan menurunkan tekanan darah sistolik (p> 0,05). Namun, ada perbedaan yang signifikan dalam penurunan tekanan darah diastolik (p = 0,045). Metode pemulihan menggunakan cairan isotonik (K3) menunjukkan penurunan tekanan diastolik tertinggi dibandingkan dengan perlakuan lainnya. Hasil analisis uji beda menunjukkan perbedaan yang signifikan dalam denyut nadi setelah perlakuan di setiap kelompok (p = 0,013). Hasil yang sama juga ditemukan untuk nilai perbedaan antar perlakuan (p = 0,004). Penelitian ini menunjukkan bahwa kelompok pemulihan aktif (K2) dan kelompok cairan isotonik (K3) memiliki penurunan denyut nadi yang paling signifikan dibandingkan dengan kelompok lainnya. Metode pemulihan dengan mengkonsumsi cairan isotonik menunjukkan penurunan tekanan diastolik dan denyut jantung tertinggi setelah latihan intensitas tinggi dibandingkan dengan perlakuan lainnya dan metode pemulihan aktif setelah latihan menunjukkan penurunan denyut jantung paling signifikan setelah latihan.

Kata kunci: metode pemulihan, cairan isotonik, air kelapa, pemulihan aktif

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INTRODUCTION

Athletes who participate in competitive sports are often faced with grueling training sessions. Inadequate recovery after high-volume training can place a significant physiological burden on the nervous system, immune system, metabolism, and muscles (Jurasz et al., 2022; Barahona-Fuentes et al., 2020). This has the potential to cause negative effects on athletes. Failure to recover from fatigue after high-intensity training sessions can result in physiological and psychological stress that can interfere with performance and increase the risk of injury (Brooks et al., 2022; Reza, 2020). Therefore, recovery strategies are considered an important component of post-exercise programs. Proper recovery after exercise can reduce fatigue and improve physical performance (Kellmann et al., 2018; Doeven et al., 2018).

Several post-exercise recovery methods have been widely recommended. In general, recovery methods are classified into two categories, namely active and passive recovery. Active recovery can include submaximal physical activity and stretching exercises, while passive recovery includes rest conditions where the body is not under stress from exercise (Mor, 2017; Andriana et al., 2022). Previous studies have reported that active and passive recovery can improve recovery and reduce muscle damage. Active recovery methods through submaximal activity can cause greater blood flow to the muscles and prevent blood pooling in the veins after exercise (Nalbandian et al., 2017; Ortiz et al., 2019).

In addition, when doing high intensity exercise, the body often sweats a lot. (O'Neal et al., 2020; Cronin et al., 2016). Conditions of sweat loss and lack of fluid intake can trigger dehydration after exercise. (Evans et al., 2017; Kim & Kwak, 2019). Therefore, rehydration through fluid administration is highly recommended to replace fluids lost during exercise. Various types of rehydration fluids are widely recommended, including isotonic fluids and green coconut water. (Chaubey et al., 2017; Wong et al., 2021).

During exercise, the human body utilizes the circulatory and cardiovascular systems, which are essential physiological systems for athletes. These systems play a vital role in transporting nutrients to the body's organs and removing waste products from the body. (Grabitz et al., 2023; Baumgartner et al., 2019; Senatorova & Onikiienko, 2020). The cardiovascular system responds differently to different types of exercise. Simple methode and non-invasive measurements for analyzing cardiovascular responses are blood pressure and heart rate. There is a clear relationship between heart rate and cardiovascular health. Heart rate is a very important and easily measured index of heart muscle function. The heart rate response to exercise and its decline during recovery are excellent markers for assessing the autonomic function of the heart muscle. (Grabitz et al., 2023; Baumgartner et al., 2019; Lundstrom et al., 2023). To date, to the author's knowledge, there has been no research comparing various recovery methods such as coconut water, isotonic fluids, with active recovery and passive recovery on heart rate and blood pressure after exercise simultaneously. This study aimed to assess the effects of different recovery methods and rehydration fluids on heart rate and blood pressure. It is hoped that this research will yield conclusions about rapid recovery programs to address post-exercise fatigue..

METHODS

This study is an experimental study with a pretest and posttest group design. The sample in this study consisted of male athletes from various sports who met the inclusion and exclusion criteria.

Subjects Characteristics

The inclusion criteria were: (a) aged ≥18 years, (b) actively involved in a sports team, (c) no injuries or muscle pain, (d) no cardiovascular or lung diseases, and (e) willing to be a research subject. The exclusion criteria in this study were subjects who used ergogenic aids and had active

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lower extremity injuries or muscle pain. The sample consisted of 24 subjects who were randomly divided into 6 groups (1 group consisted of 4 people). The sample calculation used Federer's formula as follows:

$$(n-1)(t-1) \geq 15$$
$$(n-1)(6-1) \geq 15$$
$$(n-1)(5) \geq 15$$
$$5n \geq 15 + 5$$
$$n \geq 4$$

The minimum total sample size plus 10% to account for dropouts, so n = 5.

Table 1 presents the findings of subjects characteristics. The findings indicate that the variables of height, weight, BMI, and VO2max did not differ significantly (p>0.05). Since the initial conditions of the respondents were the same for all groups, this result suggests that the initial conditions of the respondents will not have an impact on how treatment is administered.

Table 1. Subjects characteristics

Groups	**Height (cm)**	**Weight (kg)**	**BMI (kg/m²)**	**Body Fat (%)**	**VO2max**
K1	164.8±3.6	66.7±9.2	24.5±2.7	19.6±1.3	40.2±1.2
K2	164.8±6.4	63.1±12.3	23.1±2.6	16.6±6.3	41.9±4.5
K3	169.0±6.7	59.5±9.6	21.1±2.5	15.3±5.7	41.9±1.0
K4	167.8±3.3	71.3±14.7	25.3±4.3	20.4±6.0	41.9±2.1
K5	167.0±2.7	62.9±7.2	22.6±2.4	17.9±4.6	39.4±1.6
K6	163.5±6.2	58.9±14.1	21.8±3.7	14.1±9.5	40.3±0.8
P-value	0.527**	0.656*	0.411*	0.403**	0.277**

*ANOVA test, **Kruskal-Wallis test

Instruments

The characteristic data collected included age, height, weight, body mass index, and VO2max. Weight was measured using Body Impedance Analysis (BIA) digital scales (Omron, Japan) and height was measured using a microtoise. Body mass index is analyzed using Ministry of Health criteria. VO2max is measured using the Yoyo intermittent recovery test level 1 (YYIRT1) and the level of perceived exertion is measured using the modified Borg Scale 1-10.

Intervention implementation

Prior to data collection, samples were instructed not to engage in strenuous physical activity for 24 hours before testing and not to consume caffeine or alcohol for 12 hours before testing. The samples were divided into six treatment groups, namely K1 (passive recovery group) as the control group, K2 (active recovery group), K3 (isotonic fluid group), K4 (green coconut water group), K5 (active recovery + isotonic fluid group), and K6 (active recovery + green coconut water group). K1 is recovery by sitting still. K2 is recovery by jogging for 12 minutes and dynamic stretching for 8 minutes. K3 is recovery by drinking 300 ml of commercial isotonic fluid. K4 is recovery by drinking 300 ml of coconut water. K5 is jogging and drinking isotonic fluid. K6 is recovery by jogging and drinking 300 ml of coconut water.

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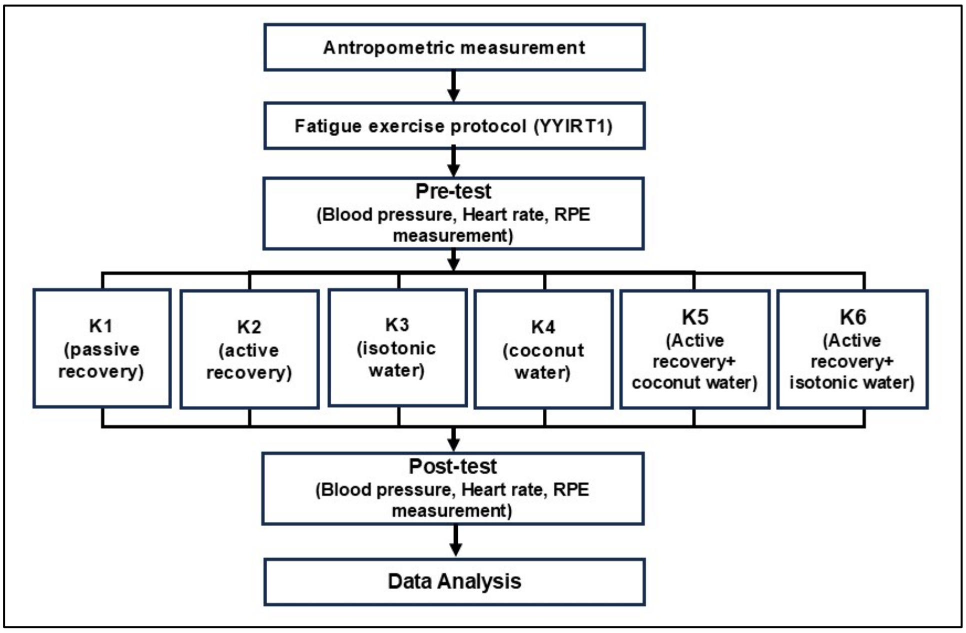

Figure 1. Schematic figure representing the experimental protocol. YYIRT1= yoyo intermitten recovery test level 1; RPE= rating of perceived exertion.

The research was conducted on a semi-indoor futsal field from 08.00 to 10.00 WIB with a temperature of 25-26° C. Blood pressure and resting heart rate were measured using a digital sphygmomanometer (Omron HEM-7156T, Japan) with the subject sitting and feet flat on the floor. Rating of Perceived Exertion (RPE) using the modified Borg scale to assess subjective fatigue on a scale of 1-10. Then, the subject was asked to perform the Yoyo Intermittent Recovery Test Level 1 (YYIRT-1) until exhaustion. The subject ran a 2x20 m shuttle determined by 2 separate markers according to the time on the audio recording. The subject was asked to touch the first marker as close as possible to the time when the first sound was emitted from the audio recording, then turn around and return to the final marker before the second sound appeared. The frequency of the sound signal in the recording was increased so that the running speed increased by 0.5 km per hour every minute from the initial speed of 8.5 km per hour. When the subject missed two non-consecutive shuttles marked by a beep, the test was ended and the maximum level achieved was recorded. Next, the subjects were asked to perform a 20-minute post-exercise recovery procedure based on their respective groups. Immediately after the test was completed, blood pressure, heart rate, and RPE were measured in each group.

Data analysis

Statistical analysis was performed using SPSS. The effects of treatment between groups were analyzed using ANOVA with Duncan's post hoc test. The significance level of the test was set at $p \leq 0.05$.

RESULTS AND DISCUSSIONS

Effect of recovery method and rehydration fluid on blood pressure

Table 2 present the effect of recovery method and rehydration fluid on blood pressure. The results of this study indicate that active recovery, passive recovery, rehydration fluid administration, and their combination did not reduce systolic blood pressure ($p>0.05$). However, there was a significant difference in the reduction of diastolic blood pressure ($p=0.045$). The recovery method using only isotonic fluids (K3) showed the highest reduction in diastolic pressure

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compared to the other treatments. These results suggest that administering isotonic fluid can effectively reduce post-exercise diastolic blood pressure. Diastolic blood pressure data in group K6 or active recovery and isotonic water showed an increase of 7.8±3.0 points.

Table 2 Effect of recovery method and rehydration fluid on blood pressure

Group	Systolic (mmHg)			Diastolic(mmHg)		
	Before	**After**	**Difference**	**Before**	**After**	**Difference**
K1	143.3±10.3	119.5±3.1	-23.8±12.3	79.8±9.0	76.3±6.6	-3.5±5.8
K2	138.8±17.4	121.8±3.5	-17.0±16.7	79.5±9.1	79.3±6.7	-0.3±4.5
K3	153.8±13.5	110.0±12.1	-43.8±15.6	77.0±12.3	68.0±4.5	-9.0±13.4
K4	138.5±23.2	114.3±7.5	-24.3±18.6	70.8±13.3	69.0±11.4	-1.8±3.3
K5	147.8±11.7	128.3±13.4	-19.5±13.1	83.8±10.4	79.0±7.5	-4.7±3.0
K6	132.0±11.2	112.8±12.8	-19.3±10.1	68.0±5.0	75.8±5.8	7.8±3.0
P-value	0.436*	0.141*	0.166*	0.283*	0.173*	0.045*

*ANOVA test

Effect of recovery method and rehydration fluid on heart rate

The effects of various recovery methods and rehydration fluids on heart rate are presented in Table 3. The results showed that all groups experienced a decrease in heart rate after receiving the recovery method and rehydration fluids. The results of the difference test analysis show a significant difference in heart rate after treatment in each group (p=0.013). Similar results were also found for the difference value between treatments (p=0.004). This study showed that the active recovery group (K2) and the isotonic fluid group (K3) had the most significant decrease in heart rate compared to the other groups.

Table 3. Effect of recovery metod and rehydration fluid on heart rate

Group	Before	After	Difference
K1	112.3±16.9	104.0±11.7	-8.3±8.8
K2	134.0±2.1	109.5±12.3	-24.5±10.7
K3	117.5±5.2	97.5±5.4	-20.0±5.9
K4	121.5±14.2	106.0±11.5	-15.5±5.4
K5	132.8±11.2	122.3±5.4	-10.5±7.3
K6	117.8±3.4	116.8±1.5	-1.0±4.8
P-value	0.170*	0.013*	0.004*

*ANOVA test

Effect of recovery method and rehydration fluid on RPE

The results of the Rating of Perceived Exertion (RPE) test showed that all groups receiving the recovery method and rehydration fluid experienced a decrease in scores, indicating a decrease in perceived fatigue after receiving the recovery method and fluids (Table 4). However, there was no significant difference in RPE scores between the two treatments (p=0.467). This result indicates that all recovery methods and rehydration fluid administration had nearly the same effect and did not significantly differ among the groups. Moreover, these results also show that the rehydration fluid group (K3) experienced a relatively greater decrease in scores compared to the other groups.

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Table 4. Effect of recovery method and rehydration fluid on RPE

Group	**Before**	**After**	**Difference**
K1	7.0±8.2	4.3±2.1	-2.8±1.5
K2	6.0±8.2	4.3±2.6	-1.8±1.9
K3	6.0±8.2	1.8±1.5	-4.3±1.7
K4	7.5±0.6	4.0±2.2	-3.5±1.9
K5	7.5±1.7	3.8±2.9	-3.7±2.2
K6	7.5±1.0	5.0±1.6	-2.5±1.9
P-value	0.113**	0.442*	0.467*

*ANOVA test, **Kruskal-Wallis test

Discussion

The results of this study indicate that the recovery method using only isotonic fluids (K3) showed the highest reduction in diastolic pressure compared to the other treatments. These results suggest that administering isotonic fluid can effectively reduce post-exercise diastolic blood pressure. Based on other study electrolyte or isotonic drinks can have varied effects on blood pressure after exercise, but generally, a temporary, slight increase may occur due to increased plasma volume, though studies also show a possible decrease in systolic blood pressure and heart rate after consuming electrolyte drink before exercise (Iqbal et al., 2019).

This study found unique data in the active recovery and isotonic water groups, which showed an increase in DBP of 7.8±3.0 points. According to studies, diastolic blood pressure tends to remain stable or increase slightly after exercise (Pesova et al., 2023). The increase in diastolic blood pressure is likely due to is a complex interaction between various factors that include not only increased cardiac output but also activation of the sympathetic nervous system, changes in vascular resistance, and thermoregulatory responses that together increase blood flow to active muscles (Pesova et al., 2023). It is possible that after active recovery, the subject was not given enough time to rest, so that blood pressure did not fully decrease. According to some literature, blood pressure will return to normal after resting for about 20 minutes after exercise (Eches et al., 2018)

In recovery heart rate showed that the active recovery group (K2) and the isotonic fluid group (K3) had the most significant decrease in heart rate compared to the other groups. Studies have reported that active recovery is significantly more effective than passive recovery in lowering heart rate after exercise (Andriana et al., 2022). Active recovery methods through submaximal activity can cause greater blood flow to the muscles and prevent blood pooling in the veins after exercise (Ortiz et al., 2019). It is not yet known for certain why isotonic fluids can lower the heart rate after exercise but there is potial mechanism that hydrating with isotonic beverage during recovery induced significant changes in cardiac autonomic modulation, promoting faster recovery of linear heart rate variability (HRV) indices (Moreno et al., 2013)

The results of the Rating of Perceived Exertion (RPE) test showed that all groups receiving the recovery method and rehydration fluid experienced a decrease in scores, indicating a decrease in perceived fatigue after receiving the recovery method and fluids. However, there was no significant difference in RPE scores between the two treatments (p=0.467). This result indicates that all recovery methods and rehydration fluid administration had nearly the same effect and did not significantly differ among the groups. Moreover, these results also show that the rehydration fluid group (K3) experienced a relatively greater decrease in scores compared to the other groups. Isotonic drinks assist to meet individual athletes' nutrition recovery goals by replacing fluids lost in sweat and also assist with refuelling targets to replenish glycogen stores. When aggressive re-hydration strategies are required, drinks with a higher sodium content may be more useful.(SDA, 2009)

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Dehydration when exercise is associated with dcrease of sports performance, so it is necessary to maintain a constant source of hydration and available carbohydrates during moderate and intense exercise activities (Berry et al., 2021; Reinhard & Galloway, 2022). During exercise, fluid homeostasis is deregulated when fluid availability is limited, or fluid loss is not adequately recovered (Reinhard & Galloway, 2022). In hot places, especially in tropical country, dehydration levels will be higher, resulting in greater cardiovascular stress due to the thermal increase (Berry et al., 2021). In high-intensity intermittent exercise, the use of isotonic drinks allows for maintaining the intensity of the exercise, contributing to maintaining high levels of circulating glucose and avoiding the depletion of muscle glycogen levels (Coombes & Hamilton, 2000). Isotonic fluid can improve hydration by stimulating fluid intake, reabsorption, and retention (Berry et al., 2020). This study shows that consumption of isotonic fluids and active recovery can be effective recovery measures after high-intensity exercise for athletes, particularly in lowering heart rate and blood pressure.This study has limitations, namely a relatively small sample size, which may affect the optimal results even though it is sufficient in terms of formula.

CONCLUSIONS

The recovery method using isotonic fluids showed the highest reduction in diastolic pressure and heart rate after high intensity exercise compared to the other treatments. Active recovery methode after exercise showed most significant decrease in heart rate after exercise.

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