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Curcumin Supplementation and Its Effect on Recovery Process Following Peripheral Fatigue

1st Rizki Hazazi Ali
Sport Education, School of Postgraduate Studies
Universitas Pendidikan Indonesia
Bandung, Indonesia
r.hazaziali@gmail.com

2nd Hamidie Ronald Daniel Ray
Sport Education, School of Postgraduate Studies
Universitas Pendidikan Indonesia
Bandung, Indonesia
hamidie.ronald@upi.edu

3rd Agus Rusdiana
Sport Education, School of Postgraduate Studies
Universitas Pendidikan Indonesia
Bandung, Indonesia
agus.rusdiana@upi.edu

***Abstract*— The purpose of this study was to determine the ability of curcumin for accelerating the recovery process after peripheral fatigue in human; as well as lactate clearance (LC), decrease of heart rate (DHR) and the recovery of vertical jump performance identified by the leg power (LP) and jump height (JH). 18 healthy men (age = 19.68 ± 0.7 y.o; BMI = 20.94 ± 1.43 Kg/m2; VO2Max = 49.30 ± 3.5 ml/kg/min) were divided into two groups (experiment and control) carried out the experimental trial for 4 weeks. Endurance training using ergocycle with moderate intensity (50-70% HRMax) was done 3 times a week. 1.1 gram/day curcumin consumed by experimental group and the control group was given a placebo sugar within. Measurements were made three times; baseline, week 2 and week 4. Experimental group showed increase of DHR. On the other way, LC only significantly increase at week 4 compared with the baseline. However, vertical jump performance recovery did not significantly increase. Comparing with the control group, only leg power recovery is significantly different, yet the mean of the experimental group mostly greater than control. The conclusion of this current results indicated that curcumin supplementation has potential to accelerate the recovery process due to peripheral fatigue.**

Keywords*— *Curcumin, Peripheral Fatigue, Recovery

I. INTRODUCTION

Curcumin (1,7-bis (4-hydroxy-3-methoxyphenyl) -1,6-heptadiene-3,5-dione) as known as diferuloylmethane [1] is an extract derived from the roots of turmeric and it is also a substance that gives yellow to turmeric plants [2]. Curcumin is the main polyphenol produced by turmeric or similar plants/curcuma [3]. Curcumin is widely used as anti-inflammation [4,5], anti-oxidants [6,7], anti-carcinogenic [8] and anti-cancer [9,10].

In addition, curcumin is also widely used in sport and exercise physiology fields [11,12]. Some of the curcumin's potentials are as an anti-fatigue and recovery booster substance [13–19]. The term of fatigue that's explained before is a fatigue caused by workload or exercise and related to human physiological functions/physiological fatigue [20].

Fatigue is divided into two types, central and peripheral fatigue. Central fatigue is fatigue caused by organs in the central of nervous system, the brain, spinal cord and motor neurons [21]. It is related to the increasing levels of histamine, 5-HT (serotonin), 5-hydroxyindoleacetic acid (5-HIAA), some neurotransmitter pathways, hormones, and exercise that causes the release of cytokine proteins [19,22,23]. Whereas peripheral fatigue is fatigue caused by organs outside the central nervous system or those associated with neuromuscular junction and commonly referred as muscle fatigue [21,24].

As the definition of fatigue described above, some studies related to curcumin as an anti-fatigue and recovery booster are divided into two groups. Several studies [13–19] examined the effect of curcumin related to central fatigue. The study concluded that curcumin can significantly reduce central fatigue indicators such as IL-6 and IL-1. While the study of peripheral fatigue in animal model [19] examined the effect of curcumin on lactate, which is one of the peripheral fatigue indicators and also on exercise performance.

Some previous studies related to the effect of curcumin as anti-fatigue and recovery booster are still carried out in the acute study model [13–16,18]. There are very few studies that use curcumin in the form of the chronic study, especially in relation to anti-fatigue and recovery booster [17]. In the other hand, the effect of curcumin on recovery process following peripheral fatigue in human model study is need to be more investigated [19].

II. METHODS

A. Participants

A total of 18 healthy men (age = 19.68 ± 0.7 y.o; BMI = 20.94 ± 1.43 Kg/m2; VO2Max = 49.30 ± 3.5 ml/kg/min) were recruited for this study. Inclusion criteria required individuals with <25 kg/m2 of BMI who participate in at least 2-4 hours per week of light to moderate intensity. Exclusion criteria included (1) Smoker (2) history/diagnoses of cardiovascular disease (3) regular ingestion of anti-oxidants supplements [12].

This study was primarily granted funding from Sport Education, Universitas Pendidikan Indonesia, Indonesia.

B. Study Design

A randomized controlled trial was used to examine the effect of curcumin on recovery process following periphral fatigue. All participants were divided into two groups (experiment and control) carried out the experimental trial for 4 weeks. Endurance training using ergocycle with moderate intensity (50-70% HRMax) was done 3 times a week. 1.1 gram/day curcumin consumed by experimental group and the control group was given a placebo with sugar within.

C. Measured Variables

There are some variables or indicators that represent recovery following peripheral fatigue [19,25] they are lactate clearance (LC) in mmol, decrease of heart rate (DHR) in bpm and the recovery of vertical jump performance identified by leg power (LP) in Watt/Kg and jump height (JH) in cm.

Blood sample was taken from fingertip and analyzed by lactate analyzer (Roche, Switzerland). While vertical jump performance was measured by Force Platform 3D (AMTI, USA).

D. Exercise Induced-Peripheral Fatigue Protocol

Cunningham and Faulkner test [26] was used as Exercise Induced-Peripheral Fatigue (EIPF). The main objective of Cunningham and Faulkner test is to examine anaerobic capacity [27]. But in this study, the test was only used as exercise induced-peripheral fatigue, because of the duration of test. In average, the duration of all participants were less than 60 second. It means the test qualified as short-distance sprint [21].

E. Test Procedure

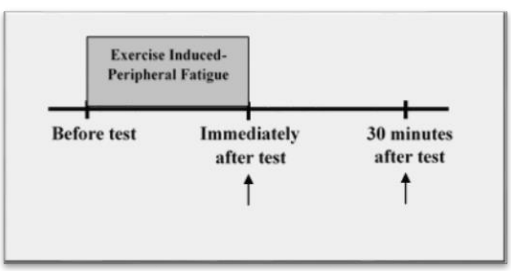

Fig. 1. Test procedure for obtaining the data

Figure 1 describes how those indicators data was obtained. This study used repeated data measurement, there were at the baseline, the middle (week 2) and the last week of the experimental trial (week 4). (showed in figure 2)

Fig. 2. Test taken timeline

F. Statistical Analysis

In this study, all statistical procedures were conducted by using SPSS 21 version while repeated measures ANOVA, independent sample t-test and mann-whitney test were used to measure those indicators data.

III. Results and Discussions

The process of taking data from each indicator was done after exercise-induced peripheral fatigue (immediately after exercise) and after the recovery process is carried out for 30 minutes (30 minutes after exercise). Because this research focuses on the recovery process due to peripheral fatigue, then the data used is the difference between the immediately after exercise data and the 30 minutes after exercise data [28]. From these data it can be seen how the recovery process of each indicator. Measurements were made repeatedly, namely at baseline, week 2 and week 4. This was done to see the impact of chronic curcumin on the recovery process due to peripheral fatigue.

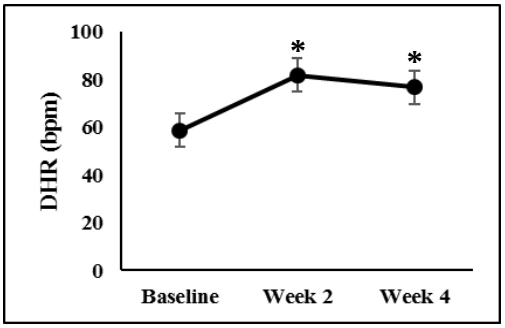

Fig. 3. Result of decrease of heart rate

Figure 3 describes the change of DHR (bpm) in all of time measurements. The within subject test result was significant ($p<0,05$) while the pairwaise comparison indicates significant difference between baseline vs week 2 (58,78 ± 17,01 vs 81,78 ± 10,84 bpm ; $p<0,05$); baseline vs week 4 (58,78 ± 17,01 vs 76,78 ± 9,95 bpm; $p<0,05$); yet the comparison between week 2 vs week 4 was not significant ($p>0,05$). (*See table 1*)

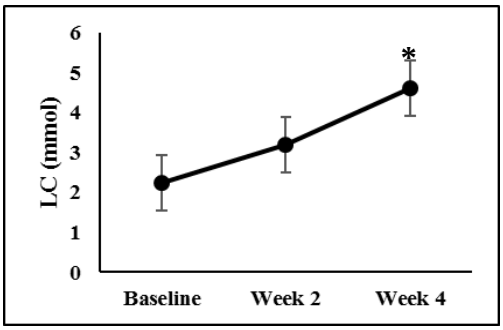

Fig. 4. Result of lactate clearance

Figure 4 describes the change of LC (mmol) in all of time measurements. The within subject test result was not significant (p>0,05) while the pairwaise comparison indicates significant difference only between baseline vs week 4 (2,24 ± 3,47 vs 4,61 ± 2,50 mmol; p<0,05). (*See table 1.*)

The exercises used in this study are exercises with endurance training types. Endurance training used in this study is continuous training. In this study, lactate clearance in the experimental group produced a significant difference between baseline and week 4 after continuous training. This is in line with previous research which revealed that endurance training affects lactate clearance [29–31]. The use of other types of exercises need to be further investigated

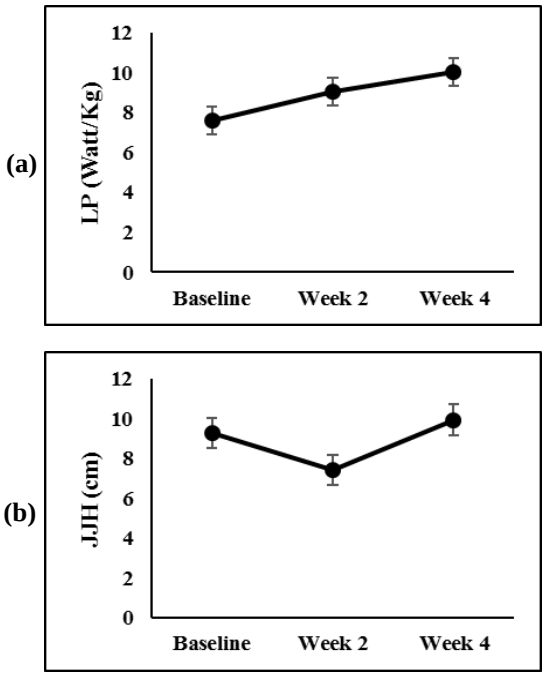

Fig. 5. Result of vertical jump performance recovery (a) leg power (b) jump height

Figure 5 (a) and (b) represent the change of LP (Watt/Kg) and JH (cm) recovery. Both of those indicators had similar result in the within subject test, it was not significant (p>0,05). Also the pairwaise comparison indicates no significant between all of time measurements (p>0,05).

TABLE I. THE RESULT OF ALL INDICATORS IN EACH TIME MEASUREMENTS. THE DATA REPRESENTS AS MEAN ± STANDARD DEVIATION.

Variable	Time Measurement		
	Baseline	***Week 2***	***Week 4***
DHR (bpm)	58,78 ± 17,01	81,78 ± 10,84	76,78 ± 9,95
LC (mmol)	2,24 ± 3,47	3,20 ± 2,00	4,61 ± 2,50
LP (Watt/Kg)	7,61 ± 6,13	9,06 ± 5,62	10,04 ± 5,46
JH (cm)	9,26 ± 5,55	7,41 ± 3,07	9,94 ± 3,24

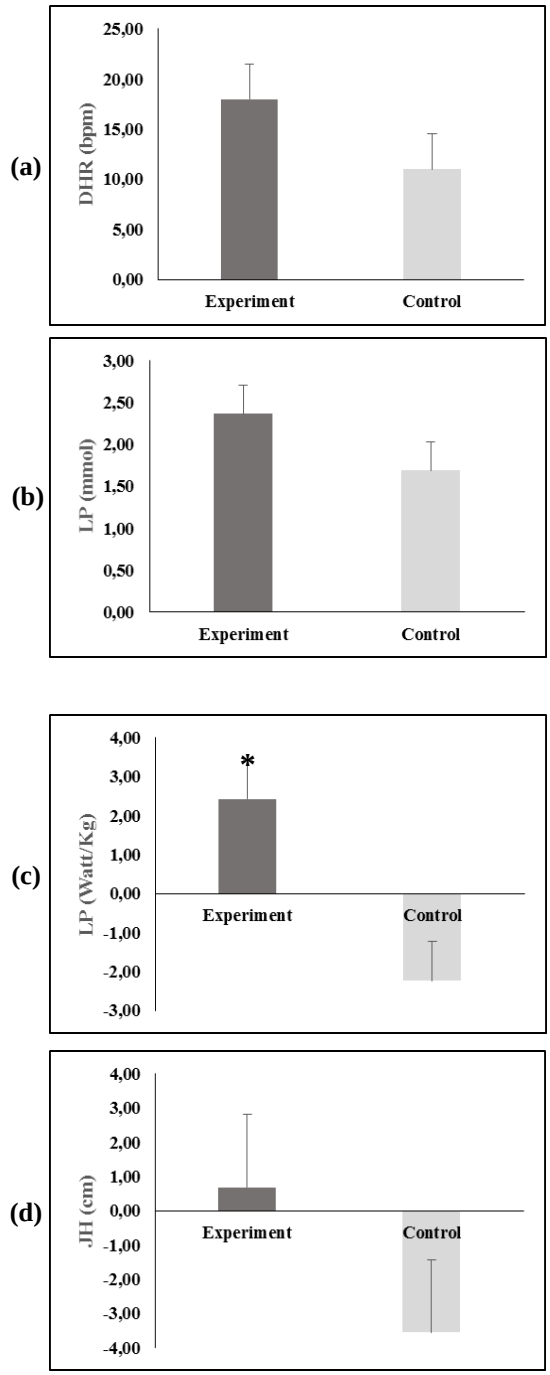

Fig. 6. Comparison between experiment and control group. (a) decrease of heart rate (b) lactate clearance (c) leg power recovery (d) jump height recovery in every single time measurements.

The comparison between exeperiment vs control group in each indicators didn't show a significant differences (p>0,05). However, the mean of experiment group seems greater than control group. Only DHR shwos the mean of control group is bigger than experiment group

These results were obtained from the experimental results of curcumin supplementation at a dose of 1100 mg daily for endurance training with a duration of 60 minutes at moderate intensity (70-80% DNM) carried out 3 times a week. The experimental process is carried out for 4 weeks or about 30 days. Previous studies conducted by Basham et al. [17] produced results that were almost similar to this study. Experiments carried out for 28 days are still considered lacking to be able to see the effect of curcumin supplementation on the recovery process. What distinguishes from this research, Basham tested curcumin against several markers of central fatigue.

Apart from the duration of the experiment, the dose of curcumin used will also affect the results of the study. Previous studies conducted by Nicol et al. [18] used a fairly high dose of 2.5 grams / day up to 50 mg / day, a study conducted by Oliver et al., [32]. Orally, curcumin has a tendency to be difficult to absorb [33], even 8,000 mg of curcumin still can't significantly increase its serum levels [34] (although several other studies have noted only 4,000 mg [35] or 8,000 mg were able to reach 22-41 ng/mL [36]). Therefore, modifications to curcumin supplements are investigated to increase the amount of curcumin that can reach the circulation needed.

The type of curcumin used will also greatly affect the results of the study. This study uses curcumin with a local trademark namely Borobudur (Semarang) with a dose of 1100 mg / day. The difference in the type of curcumin is related to the level of bioavailability. Bioavailability is the ability of a given substance that is able to be absorbed and stored or used by the body [37]. Jamwal et al [38] research results related to the bioavailability of the types of curcumin that have been developed when compared with ordinary curcumin.

Another thing to note is the measurement of peripheral fatigue. Indicators in this study include heart rate recovery (DHR), lactate clearance (LC), leg power (LP) and jump height (JH) recovery as indicators of the recovery process due to peripheral fatigue. Because it is related to the neuromuscular junction, several indicators such as acidity (pH) and some related ions need to be observed further [21,24]. In addition to this, the measurement of muscle performance should also be considered, the use of tools such as EMG can also be a consideration because it is considered specific in evaluating muscle performance [39–41].

IV. Conclusion

These current results indicated that curcumin supplementation has potential to accelerate the recovery process due to peripheral fatigue. Adding more duration to the experimental trial, using high bioavailability curcumin and try some type of different exercise (HIIT, resistance training etc) are valuable to be more investigated.

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