Effect of acupuncture on decreasing blood lactate levels after exercise in elite basketball athletes

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Abstract. The study aim was to determine if acupuncture at the PC 6 Neiguan and ST 36 Zusanli points could decrease blood lactate levels in elite basketball athletes after exercise. We conducted a randomized controlled trial in 36 elite basketball athletes divided into 2 groups: the acupuncture group (n = 18) and control group (n = 18). In the acupuncture group, acupuncture was performed at the PC 6 Neiguan and ST 36 Zusanli points for 20 minutes. In the control group, no intervention was performed. Before the first session and after the twelfth, the athletes performed a specified exercise. Blood lactate levels were measured at 5 minutes and 25 minutes after exercise by using a portable blood lactate analyzer to determine the decrease due to clearance. In the acupuncture group, the decrease in blood lactate levels improved from 3.94 ± 1.11 mmol/l (study beginning) to 5.24 ± 1.22 mmol/l (study end). In the control group, the decrease in blood lactate levels improved from 3.59 ± 1.26 mmol/l (study beginning) to 3.78 ± 1.11 mmol/l (study end). The decrease in lactate levels after exercise in elite basketball athletes was significantly greater after acupuncture treatment than in the control group.

1. Introduction
In sports, recovery after exertion is a very important process for athletes. Athletes may compete more than once in a day in a competition. Therefore, a fast recovery ability is essential to athletes [1]. Professional athletes are often involved in high-intensity exercise, which increases lactic acid in muscles. The accumulation of lactic acid in muscles is often associated with muscle fatigue [1,2]. The clearance rate of lactic acid accumulation is indicated by the decrease in lactate levels in blood, which is used as a criterion to assess the quality of the recovery rate of athletes [2]. Several studies have shown that the clearance rate of lactic acid associated with the recovery rate of athletes could be increased by several modalities, such as acupuncture, massage, active recovery, hyperbaric oxygen therapy, compression stocking, and stretching [3].

Acupuncture is one of the modalities that can accelerate the clearance of lactic acid, thus, improving the recovery ability of athletes [3,4]. Lin et al. (2009) conducted a study in 30 professional basketball athletes randomized into 3 groups: the acupuncture group, sham group, and control group (n = 10 athletes, each). In the study, the PC 6 Neiguan and ST 36 Zusanli acupuncture points were used in treatment given 15 minutes before exercise on a bicycle ergometer. The results showed that the lactic acid levels measured at 5 minutes, 30 minutes, and 60 minutes after exercise were lower in the acupuncture group than in the other groups (p < 0.05) [5,6]. Chen et al. (2009) conducted a study in 24 professional basketball athletes divided into 2 groups: the acupuncture group and control group. This
study used the ear acupressure points of shenmen, heart, lung, liver, sanjiao, adrenal cortex, and endocrine that were used in treatment given 30 minutes before exercise on a bicycle ergometer and continued until the exercise was finished. The results showed that the levels of lactic acid measured at 30 minutes after exercise were lower in the acupuncture group than in the control group (p < 0.05).

Both of the studies above concluded that acupuncture had a positive effect on accelerating the recovery ability of athletes after exercise. The aim of this study was to determine the effect of acupuncture on blood lactate levels in elite basketball athletes after exercise.

2. Methods
A single-blind randomized controlled trial test with control was conducted, the study protocol was approved by the Health Research Ethics Committee, Faculty of Medicine Universitas Indonesia-Cipto Mangunkusumo Hospital. The study sample comprised elite basketball athletes in Indonesia who met the inclusion criteria and did not meet the exclusion criteria. The inclusion criteria of this study were healthy elite basketball athletes, confirmed by anamnesis and physical examination, vital sign examination (blood pressure, pulse rate, temperature), who were willing to provide signed informed consent and were willing to complete the study. The exclusion criteria were athletes in an unhealthy condition, injured, or undergoing an injury rehabilitation process. The drop-out criteria were athletes who did not undergo acupuncture therapy more than two times.

The study was started by having the subjects perform a high-intensity exercise procedure. The exercise began with warming and stretching for 10 minutes and, then, continued with high-intensity exercise, which involved sprinting across a basketball court 17 times, a zigzag run along the basketball court 4 times, and skipping in a 30-cm box 6 times. After that, the lactate levels were measured at 5 minutes and 25 minutes after high-intensity exercise with the athletes in a sitting position. Aseptic and antiseptic procedures were performed; then, the tip of the ring finger was pierced by using a lancet. Blood was placed on a blood lactate strip and, then, was measured by using a portable blood lactate analyzer.

In the acupuncture group, the acupuncture procedure was performed with the subjects in a lying or sitting position. Aseptic and antiseptic procedures were performed at the acupuncture points prior to piercing. Needle placement was performed at the PC 6 Neiguan point to a 10–20 mm depth and at the ST 36 Zusanli point to a 20–30 mm depth. Then, after deqi sensation, the needle was left in place for 20 minutes. The PC 6 Neiguan acupuncture point was located 2 inches above the wrist (when the hand was in the supine position) between the palmaris longus muscle tendon and flexor carpi radialis (Figure 1). The regional anatomy included skin-subcutaneous tissue between the flexor carpi radialis muscle tendon and palmaris longus muscle tendon, flexor digitorum superficialis muscle, flexor digitorum profundus muscle, and muscle-pronator quadratus muscle. The innervation included the medial and lateral antebrachial cutaneous nerve and palmar cutaneous branch of the median nerve inside the anterior interosseous nerve.

![Figure 1. PC 6 Neiguan Point](Source: World Health Organization (WHO). WHO standard acupuncture point locations in Western Pacific regions. Geneva: World Health Organizations. 2009; 154.)
The ST 36 Zusanli acupuncture point was located at the anterolateral side of the leg in a flexed knee position 3 inches below ST 35 Dubi and 1 finger from the lateral side of the anterior tibial crista (Figure 2). (ST 35 Dubi: flexed knee position at the curve below the knee and lateral side of the patella ligament). The regional anatomy included the skin, subcutaneous tissue, anterior tibialis muscle, interosseous membrane of the leg posterior tibialis muscle, and lateral cutaneous nerve. The innervation included the lateral cutaneous nerve of the calf and cutaneous branch of the saphenous nerve in the deep peroneal nerve.

Figure 2. ST 36 Zusanli Point
Source: World Health Organization (WHO). WHO standard acupuncture point locations in Western Pacific regions. Geneva: World Health Organizations. 2009; 64.

3. Results
This study was conducted in 36 subjects who met the inclusion criteria and who were divided randomly into 2 groups: the acupuncture group and the control group (n = 18 each). Prior to the study, the subjects were briefed about the study procedure. All the subjects successfully completed the study (there were no drop-out subjects). The samples were collected in the form of capillary blood placed on a lactate strip and, then, analyzed by using a portable blood lactate analyzer.

3.1 Subject Characteristics

| Variable            | Acupuncture (X ± SD) | Control (X ± SD) | p-value |
|---------------------|----------------------|------------------|---------|
| Age (years)         | 21.8 ± 1.85          | 21.7 ± 1.83      | 0.544   |
| Systolic Blood Pressure | 110 ± 7.5        | 109 ± 7.4        | 0.062   |
| Diastolic Blood Pressure | 75 ± 4.7           | 74 ± 4.9         | 0.087   |
| Pulse Rate          | 64.9 ± 4.5          | 66.6 ± 3.9       | 0.162   |
| Temperature         | 36.4 ± 0.43         | 36.4 ± 0.46      | 0.107   |
| Body Mass Index     | 22.5 ± 2.86         | 23.3 ± 1.93      | 0.704   |
Table 1 shows the subject characteristics of age, blood pressure, pulse rate, temperature, and body mass index. There were no significant differences (p < 0.05) in the subject characteristics between the groups.

Table 2. Lactate Levels at 5 minutes and 25 minutes After Exercise Before the Intervention (Beginning of the Study)

| Time                  | Acupuncture (X ± SD) | Control (X ± SD) | p-value |
|-----------------------|----------------------|------------------|---------|
| 5 minutes after exercise | 10.88 ± 1.30         | 10.53 ± 1.56     | 0.471   |
| 25 minutes after exercise | 6.94 ± 0.60          | 6.94 ± 0.57      | 1.00    |
| Decrease              | 3.94 ± 1.11          | 3.59 ± 1.26      | 0.384   |

Table 2 shows that there was no significant difference in the mean blood lactate levels 5 minutes after exercise at the study start between the acupuncture and control groups. There was no significant difference in the mean blood lactate levels 25 minutes after exercise at the study start between the acupuncture and control groups. There was no significant difference in the mean decrease in the lactate levels from 5 to 25 minutes after exercise at the beginning of the study between the acupuncture and control groups.

Table 3. Lactate Levels at 5 minutes and 25 minutes After Exercise After the Intervention (End of the Study)

| Time                  | Acupuncture (X ± SD) | Control (X ± SD) | p-value |
|-----------------------|----------------------|------------------|---------|
| 5 minutes after exercise | 11.05 ± 1.30         | 10.48 ± 1.48     | 0.233   |
| 25 minutes after exercise | 5.80 ± 0.50          | 6.70 ± 0.73      | 0.001   |
| Decrease              | 5.24 ± 1.22          | 3.78 ± 1.11      | 0.001   |

Table 3 shows that there was no significant difference in the mean blood lactate levels 5 minutes after exercise at the end of the study between the acupuncture and control groups. There was a significant difference in the mean blood lactate levels 25 minutes after exercise at the end of the study between the acupuncture and control groups. There was a significant difference in the mean decrease in the lactate levels from 5 to 25 minutes after exercise at the end of the study between the acupuncture and control groups.

4. Discussion

The study results showed that acupuncture at the PC 6 Neiguan and ST 36 Zusanli points significantly decreased the lactate levels of elite basketball athletes after exercise in accordance with the study hypothesis. However, other factors may have also affected the decrease in the lactate levels, such as the physical status of each athlete, supplements, or recovery modalities used by the athletes. In this study, several subjects in the control group showed faster decrease in the lactate levels at the end of the exercise although they received no acupuncture intervention.

The PC 6 Neiguan and ST 36 Zusanli points were selected according to evidence provided in previous studies that used both points to decrease lactate levels to accelerate recovery process of athletes after exercise. The rationale in selecting the points was not explained; however, it was known that both points could increase blood flow. The mechanism for increasing blood flow is described below.

A case study of Yoshito Mukaino was conducted to determine the effect of acupressure stimulation of the ST 36 Zusanli point on fatigue and to observe fatigue recovery by measuring the changes in partial pressure of carbon dioxide on the skin. The results showed that the stimulation of the ST 36 Zusanli point accelerated fatigue recovery. The authors explained that the effect was due to an increase in microcirculation [7].
According to a study by Sheng Hsiung Hsiao, the stimulation of the ST 36 Zusanli point could increase blood flow by modulating the production of nitric oxide (NO). The study explained that acupuncture induced mechanical transduction in connective tissue immediately after the needle was placed. The mechanical transduction passed into the extracellular matrix, which is a multi-component tissue that can transmit mechanical signals, both internal and external, that altered the function and structure of tissue. The mechanical transduction modulated the production of NO and mediated the vascular circulation [8].

A study conducted by Tsuchiya et al. concluded that the PC 6 Neiguan and ST 36 Zusanli points stimulated the release of NO, which resulted in increased blood flow. It is known that NO has several functions, including regulatory function of blood vessels and blood flow. NO is produced by 3 NO synthase (NOS) isoforms: neuronal NO synthase (nNOS), inducible NO synthase, and endothelial NO synthase (eNOS) [9].

In the vascular wall, NO derived from eNOS diffuses into smooth muscle blood vessels and reacts with hemoglobin from red blood cells, which transports oxygen and carbon dioxide. Blood transports the oxygen complex with hemoglobin into all parts of the body to support metabolism and transports carbon dioxide back to the lung, where gas exchange occurs [10,11].

Recently, nNOS had been identified as a source of NO, which also has a role in the vascular function. Thus, NO could be produced and transported to vascular smooth muscle from endothelial cells and perivascular nerve fibers [10,11].

Acupuncture stimulates the release of NO from the endothelium, and NO bound with guanil cyclase increases the production of cyclic guanosine 3',5'-monophosphate (cGMP). The activation of NO-guanil cyclase-cGMP induces vasodilatation of the blood vessels, which increases blood circulation. cGMP increases intracellular calcium, which leads to vasodilatation of the blood vessels [10,11].

It is known that exercise improves the performance of athletes, and the modality used can accelerate the recovery of athletes after exercise. In this case, the regular use of acupuncture therapy could be useful in shortening recovery times. Acupuncture could be performed before, during, or after a competition.

A limitation of this study was that the lifestyle factors of each subject might have varied and affected the study outcomes. Therefore, it is desirable that external factors that may affect outcomes be controlled in future studies. Another limitation is that performance of the high-intensity exercise by the subjects may have varied because this type of exercise is tiring; therefore, the commitment of each subject during exercise may have varied.

Acupuncture is a relatively safe procedure. In this case, acupuncture was used as an adjunctive therapy or modality to accelerate the recovery of athletes after exercise by accelerating the decrease in the lactate levels in muscles, as reflected by the change in decrease of the blood lactate levels due to natural clearance over a period of exercise. Acupuncture can be applied because it is simple and well tolerated by patients. No side effects were observed in this study.

5. Conclusion
In this study, we demonstrated that the decrease in the blood lactate levels after exercise in elite basketball athletes was significantly greater after acupuncture treatment than in the control group.

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