Effects of auricular acupuncture on heart rate, oxygen consumption and blood lactic acid for elite basketball athletes

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Abstract: This study investigated the effects of auricular acupuncture on athletes' recovery abilities after exercise. Subjects were selected from twenty-four male elite university basketball players, randomly divided into two groups: auricular acupuncture group (AAG), and normal control group (NCG), each group containing twelve subjects. Auricular acupuncture was experimented to each AAG athlete while no auricular acupuncture was conducted to each NCG athlete. Each subject in both

groups performed a ride on the stationary bike until exhausted. The data of heart rate (HR_{max}), oxygen consumption (VO_{2max}), and blood lactic acid were measured at four points of time: during the rest period after warm-ups and at the 5th, 30th and 60th minutes post-exercise, respectively. One-way ANOVA and repeated Scheffé methods were used to test the differences of the data among these two groups. The results showed that both HR_{max} and blood lactic acid in AAG were significantly lower than those in NCG at the 30^{th} and 60^{th} minutes post-exercise. It suggests that auricular acupuncture can enhance the athletes' recovery abilities after aggressive exercises.

Keywords*:* Auricular acupuncture; Basketball athlete; Heart rate; VO_{2max}; Blood lactic acid.

Remarks:

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Introduction

Traditional Chinese Medicine (TCM) users have long enjoyed a sense of participation in their own healing, with a sentiment of congruence between the medicine therapies and their personal values and/or philosophical orientation (Cassidy, 1998; Barnes *et al*., 2004; Burke *et al.*, 2006; Chen *et al*., 2007; Chung *et al*., 2007). TCM techniques include acupuncture, herbal medicine, moxibustion, Tai Chi, Qigong, among others. Of them, acupuncture and herbal medicine are perhaps the two most commonly-used complementary medicine therapies (Manheimer *et al*., 2009). In fact, acupuncture has long been used to treat illnesses or to release pains or stresses for thousands of years (Cabioglu and Cetin, 2008; Lin and Chen, 2008). The World Health Organization (WHO) acknowledged that acupuncture can treat more than fifty illnesses (Lin *et al.*, 1996). Liang *et al.* (2003) found that acupuncture can enhance the recovery in rate of perceived exertion, self-report emotional state and isokinetic muscle power output. Itoh *et al.* (2008) reported that acupuncture can reduce inflammation and decrease pain in delayed onset muscle soreness (DOMS). A review on acupuncture analgesia in dental pain concluded that acupuncture is effective (Ernst and Pittler, 1998). Acupuncture has also been used to help recover from athletes' muscle fatigue after aggressive training or fierce competitions. Qu *et al.* (1993) found that acupuncture treatment to a fatigued muscle, immediately after three hours of

continuous contraction, can result in a 5% improvement in muscle tension output. Wang *et al.* (1999) also reported that acupuncture can enhance the recovery of muscle force capacity after exercise. Lin *et al.* (2009a) found that the development of effective acupuncture schemes can enhance the recovery ability for basketball athletes. Hsieh (2010) showed that auricular acupressure employing Japanese Magnetic Pearls or vaccaria seeds can reduce the BMI and that the vaccaria seeds have the greatest reduction. Wu et al. (2011) [後面references並無此文獻] remarked that both auricular and body acupuncture treatment methods are effective in reducing anxiety in preoperative patients.

Electroacupuncture, applying electric stimulation on the needles during acupuncture, is also reported effective in treating various clinical conditions. Knardahl *et al.* (1998) demonstrated that electroacupuncture can increase pain threshold. Electrostimulation of acupuncture points produces analgesic effects which are mediated by the release of different neuropeptides, depending on the stimulation frequency (Han, 2004). Ulett *et al.* (1998) also showed that electroacupuncture appears to be more effective than manual acupuncture in producing analgesic effects. Furthermore, transcutaneous electrical acupoint stimulation (TEAS) has been used to treat various clinical conditions and the reports indicated that TEAS appears to be

effective in reducing post-operative nausea and vomiting (Coloma *et al.*, 2002; White *et al.*, 2002, 2005).

Auricular acupuncture (AA), a distinct form of acupuncture, is based on a somatotopic relation of the external ear to other body regions (Oleson *et al*., 1980). Lin *et al.* (1995) demonstrated that ear acupressure is effective in increasing oxygen uptake and lowering lactic acid following exercise. Greif *et al*. (2002) found that auricular electrostimulation has an anesthetic-sparing effect after acute noxious stimulation. Sator-Katzenschlager *et al*. (2003, 2004) also indicated that auricular electrostimulation can enhance the effects of conventional AA in the treatment of chronic musculoskeletal pain.

Developing effective treatment schemes to help athletes quickly recover from muscle fatigue after extensive training or fierce competitions can be a challenging issue to the coaches. It is especially important prior to the international competitions to help the athletes achieve their best physiological conditions. To this end, the present study attempts to test how AA will enhance the physiological abilities by lowering athletes' heart rates at rest, decreasing oxygen intake, and expediting excretion of post-exercise blood lactic acids. This study aims to conduct a scientific experiment on some elite basketball athletes to gain evidence of the effects of AA stimulation.

Methods

Participants

Twenty-four elite male basketball athletes (aged: 21.2±1.2 years, height: 184.1±2.3cm, weight: 81.8± 3.04 kg, training duration: 6.7 ±1.0 years) from the University of Physical Education, Taiwan were selected to participate in this experimental study. These athletes were randomly divided into two groups: auricular acupuncture group (AAG, n=12), and normal control group (NCG, n=12).

Experiment settings

During the experiment, each participant from both groups rode the stationary bike until completely exhausted, which was determined by the participant himself. Initially, the speed was set 60 RPM with energy power 120W, but it was increased by 30W every two minutes.

One recent study (Lin et al., 2009b) reported that AA at such acupoints as Shen Men, Heart, Lung, Liver, Triple Warmer, Adrenal Cortex, and Endocrine has positive effects on improving the recovery ability for national boxing athletes. Accordingly, the present study selected Shen Men, Heart, Lung, Liver, Triple Warmer, Subcortex, and Pituitary Gland, as depicted in Figure 1, as the seven auricular acupoints for the

experiment. A total of fourteen magnetic stud patches were applied to these acupoints on both ears of each AAG participant 30 minutes prior to the stationary bike exercise and lasting until the end of experiment. For each NCG participant, exactly the same experiment settings were undertaken except that the “magnetic stud patches” on both ears were replaced by the ordinary “3M tapes,” which had no AA stimulation effects at all.

All the participants in both groups were fully informed of the experiment process and the usage of the equipment. However, each participant in both groups did not know about whether “magnetic stud patches” or “3M tapes” have been applied to his ears throughout the experiment. To prevent from injury before the experiment, each participant was enforced with sufficient warm-ups.

Equipment and Process

The experiment was conducted in the laboratory. The following equipment and instruments were used: (1) SENSOR MEDICS Vmax29 Gas Meter. (2) YSI2300 PLUS Lactate Analyzer. (3) 586 PIII Computer and Laser Printer. (4) POLAR Mobile Heart Rate Recorder. (5) Stopwatch. (6) Hygrometer. Of them, wireless heart recorder (POLAR), Vmax29 gas analyzer, and YSI2300 lactic acid analyzer were used to analyze the heart rate, oxygen consumption, and blood lactic acid, respectively.

Each subject was conducted two-phase experiments and was required to wear a mask and a breathing collector. In the first phase, all participants warmed up their muscles on the stationary bike till the RQ indicator reached 0.7-0.8 on the Vmax29c [Vmax29c or Vmax29？何者正確請確認。上面第 1 種儀器不是Vmax29 Gas Meter 嗎?]. In the second phase, the magnetic stud patches were applied to AAG subjects and the 3M tapes were applied to NCG subjects. The investigation for each participant from both groups was measured on four points of time: during the rest period prior to exercise and during the recovery period at the 5^{th}, 30^{th} and 60^{th} minutes post-exercise, respectively.

Data Analysis

SPSS 12.0 for Windows was used for the data analyses. First, a descriptive analysis on the age, height and weight of the participants was conducted. Then the one-way ANOVA and repeated Scheffé methods were employed to test the differences of heart rate (HR_{max}), oxygen consumption (VO_{2max}), and blood lactic acid between two groups, prior to and after the exercise at different points of time. The level of statistical significance was set at $P < 0.05$.

Results

The results of one-way ANOVA and repeated Scheffé test showed that the HR_{max}, VO_{2max}, and blood lactic acid of the AAG athletes were significantly lower than those of the NCG athletes at the 30th minute post-exercise (Table 1). Both HR_{max} and blood lactic acid in AAG were significantly lower than those in NCG at the 30th and 60th minutes post-exercise. VO_{2max} in AAG was significantly lower than those in NCG at the 30th minute post-exercise. No significant difference on HR_{max}, VO_{2max} or blood lactic acid has been found between these two groups during the rest period prior to exercise and at the 5th minute post-exercise.

Discussion

It is concluded that auricular acupuncture (AA) stimulation can significantly improve the oxygen intake for athletes—the VO_{2max} per minute is higher for athletes with AA stimulation than those without the stimulation. Similar results were also found in a recent research by Lin *et al*. (2009b) who applied magnetic stud patches to national boxing athletes on their ear acupoints corresponding to Lung, Kidney, Spleen, Triple Warmer, Adrenal Cortex and Endocrine, aiming to improve their VO_{2max} during aggressive exercise. Other researchers also used VO_{2max} as an important indicator for evaluating athletes' aerobic ability as well as sport performance (e.g., Lin *et al*.,

2009a). Based on the above, it is concluded that AA stimulation could potentially enhance the athletes' aerobic ability, thus improve the athletes' sport performance.

Our results provided evidence that AA stimulation can expedite the athletes' post-exercise recovery on heart rate, oxygen consumption, and blood lactic acid. It is important for the athletes to maintain peak physiological conditions and to recover quickly during competition periods. AA stimulation can be applied to the three phases of athletic training—adjustment, training and competition. It is presumed that improvement in different phases would enhance the athletes' overall training efficacies and performance results; thus, it is recommended to develop proper AA schemes to help recover the athletes' aerobic abilities to maintain their peak conditions.

It is inevitable that this study has some limitations and requires further exploration. AA is a diagnostic and treatment system based on normalizing the body's dysfunction through stimulation of some definite points on the ears—its reflex system has not yet correlated with modern knowledge of anatomy and physiology. The experiment was conducted in a laboratory—a controlled environment where interference variables can be ignored. It is reasonably believed that deviated results may be obtained in real-world competition contexts or uncontrolled environments. Thus, it calls for conducting similar AA experiments in the contexts of athletic

competition in the future. Besides, future studies can also validate the direct relationships between athletes' AA stimulation and their sporting performance. This study showed that AA stimulation can enhance the athletes' physical capabilities by significantly improving their aerobic functions including VO_{2max} and HR_{max}. Future studies can conduct similar AA stimulation experiments to those who require extraordinary aerobic functions, such as 400-meter sprints, 800-meter runs, and even marathons to improve their sporting performance.

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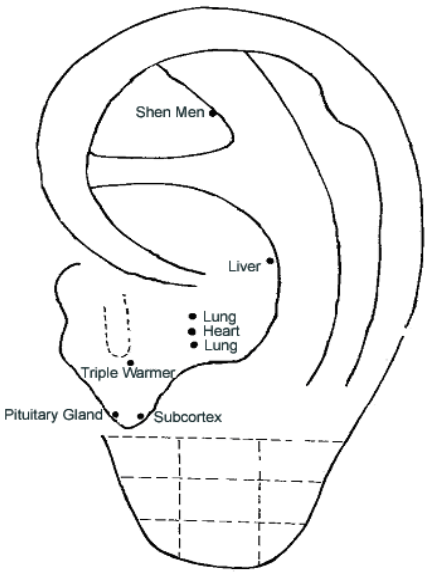

Figure 1. Distribution of simulative auricular acupoints

Table 1 Comparison of Cardiopulmonary Endurance between AAG and NCG

Variables	Auricular Acupuncture Group (AAG)	Normal Control Group (NCG)
	Mean ± SD	Mean ± SD
HR (bpm)		
Rest	66.58 ± 1.37	68.3 ± 1.05
P5	121.5 ± 1.24	122.0 ± 2.08
P30	80.25 ± 1.28[a]	83.41 ± 1.31
P60	73.08 ± 0.90 [a]	75.25 ± 2.56
VO_2 (ml/kg/min)		
Rest	4.36 ± 0.14	4.38 ± 1.12
P5	22.91± 1.24	23.58 ±1.62
P30	7.25 ± 0.18 [a]	8.07± 0.34
P60	4.18 ± 0.15	4.29 ± 0.15
Blood Lactic Acid (mmol/l)		
Rest	0.85 ± 0.01	0.83 ± 0.01
P5	9.04 ± 0.15	9.00 ± 0.01
P30	4.05 ± 0.17 [a]	4.75 ± 0.12
P60	1.26 ± 0.01 [a]	1.65 ± 0.13

[a] statistical significance ($p < 0.05$) compared with NCG