

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 treadmill 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 and during the post-exercise period at 5th, 30th and 60th minutes, respectively. One-way ANOVA and repeated Scheffé methods were used to test the differences of the data among different groups. The results showed that both HR_{max} and blood lactic acid in AAG were significantly lower than those in NCG at the 30th and 60th minute 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

Remark:

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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 been used to treat illnesses or to release pains 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 can be 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.* (2009) found that the development of effective acupuncture schemes can enhance the recovery ability for basketball athletes.

Electroacupuncture, applying electric stimulation on the needles during acupuncture, is also reported in treating various clinical conditions. Knardahl *et al.* (1998) demonstrated that electroacupuncture can increase pain threshold. Eelectostimulation 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 can be a challenging issue to the coaches. It is especially important prior to international competitions to help athletes achieve the best physiological conditions. To this end, the present study attempts to test how ear acupuncture will enhance the sporting 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 auricular acupuncture stimulation.

Methods

Participants

Twenty-four elite male basketball athletes (aged: 21.2 ± 1.2 years, height: 184.1 ± 2.3 cm, weight: 81.8 ± 3.04 kg, training duration: 6.7 ± 1.0 years) from the University of Physical Education in 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 rode the treadmill-bike until completely exhausted, which was determined by the subject. Initially, the speed was set 60 RPM with energy power 120W, and it was increased by 30W at every two minutes. Magnetic stud patches were applied on seven auricular acupoints - Shen Men, Heart, Lung, Liver, Triple Warmer - on both ears of each AAG participant 30 minutes prior to treadmill-bike exercise and the magnetic stud patches lasted until the end of experiment. Figure 1 displays the distribution of simulative auricular acupoints. Exactly the same experiment settings are undertaken for the NCG participants except that the magnetic stud patches were replaced by 3M tapes. The participants of the study were fully informed of the experiment process and the usage of the equipment. However, all participants in both groups did not know about whether magnetic stud patches or 3M tapes being applied to their ears throughout the experiment. To prevent injury during the experiment, participants prepared for exercise with sufficient warm-ups.

Equipment and Process

The experiment was conducted in a 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.

The study design included two phases. The first phase was to conduct the experiment to all subjects without the laboratory control. In the second phase, the magnetic stud patches were applied to AAG subjects, whereas 3M tapes were applied to NCG subjects. Each subject was required to wear a mask and a breathing collector. All participants warmed up their muscles on the treadmill bike till the RQ indicator reached 0.7-0.8 on the Vmax29c before the experiment took place.

The investigation was measured on four points of time: during the rest period prior to exercise and during the recovery period at the 5th, 30th and 60th minutes post-exercise, respectively. 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.

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). HR_{max} in AAG was 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. Blood lactic acid in AAG was also significantly lower than those in NCG at the 30th and 60th minutes post-exercise. No significant differences on HR_{max} , VO_{2max} and blood lactic acid have been found between two groups at the 5th, 30th and 60th minutes post-exercise.

Our results indicated that auricular acupuncture can expedite the athletes'

post-exercise recovery on heart rate, oxygen consumption, and blood lactic acid. It provided evidence that auricular acupuncture can enhance athletes' recovery abilities, which is essentially important on the eyes of competitions. This study has gained some insights into the recovery system and physiological profile of athletes by auricular acupuncture.

Discussion

Few studies discussed auricular acupuncture regarding VO_{2max} changes in elite basketball athletes. It is important for athletes and coaches to maintain peak physiological conditions and to recovery quickly during competition phases. Thus, this study can be useful in designing appropriate auricular acupuncture schemes to help level up athletes' sport performance. However, auricular acupuncture is a diagnostic and treatment system based on normalizing the body's dysfunction through stimulation of definite points on the ear. Its reflex system does not correlate with modern knowledge of anatomy and physiology.

Auricular acupuncture stimulation significantly improved oxygen intake for athletes. The VO_{2max} per minute was higher for athletes with auricular acupuncture stimulation than those without the stimulation. Similar results were also found in a

recent research by Lin *et al.* (2009), wherein six males were given stimulation using auricular acupuncture patches on ear acupoints related to Lung, Kidney, Spleen, Triple Warmer, Adrenal Cortex and Endocrine with the aim of improving the VO_{2max} during aggressive exercise. Other researchers also used VO_{2max} as an important indicator for evaluating athletes' aerobic ability and sport performance. Based on the above discussion, it is concluded that auricular acupuncture stimulation could potentially enhance the athletes' aerobic ability, thus improving the sport performance.

Auricular acupuncture stimulation has become an internationally-recognized alternative therapy, which was proven with substantial improvement on the cardiopulmonary functions. In this study, auricular stimulation has shown to enhance the physical capabilities of athletes by significantly improving the aerobic function indicators such as VO_{2max} and HR_{max} . Based on our findings, auricular stimulation could be probably useful as well to improve the performance for 400-meter sprints, 800-meter runs, and even marathons. At least, our findings have shed some light in the development of effective auricular acupuncture schemes to enhance the recovery ability for elite basketball athletes.

Conclusion

Based on this study, auricular stimulation has significant effects on the VO_{2max} . Accordingly, the coaches can design appropriate auricular acupuncture schemes to recover the athletes' aerobic abilities to maintain their peak performance. It is concluded that auricular stimulation has a significant impact on cardiopulmonary functions. Therefore, it is recommended to use auricular stimulation during the three phases of training: adjustment, training and competition. Improvements in different phases for athletes may improve the training efficiency and the performance results as well.

This study 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 circumstances or uncontrolled environments. Thus, it is recommended to conduct similar auricular acupuncture experiments in the context of athletic competitions in the future. Future studies can also validate the direct relation between auricular stimulation and sporting performance.

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References

- Barnes, P.M., E. Powell-Griner, K. McFann and R.L. Nahin. Complementary and alternative medicine use among adults: United States, 2002. *Adv. Data.* (343): 1-19, 2004.
- Burke, A., D.M. Upchurch, C. Dye and L. Chyu. Acupuncture use in the United States: Findings from the National Health Interview Survey. *J. Altern. Complement. Med.* 12(7): 639-648, 2006.
- Cabioglu, M.T. and B.E. Cetin. Acupuncture and immunomodulation. *Am. J. Chin. Med.* 36(1): 25-36, 2008.
- Cassidy, C.M. Chinese medicine users in the United States. Part I: Utilization, satisfaction, medical plurality. *J. Altern. Complement. Med.* 4(1): 17-27, 1998.
- Chen, F.P., T.J. Chen, Y.Y. Kung, Y.C. Chen, L.F. Chou, F.J. Chen and S.J. Hwang. Use frequency of traditional Chinese medicine in Taiwan. *BMC Health Serv. Res.* 7: 26, 2007.
- Chung, V., E. Wong, J. Woo, S.V., Lo and S. Griffiths. Use of Traditional Chinese Medicine in the Hong Kong special administrative region of China. *J. Altern. Complement. Med.* 13(3): 361-367, 2007.
- Coloma, M., P.F. White, B.O. Ogunnaike, S.D. Markowitz, P.M. Brown, A.Q. Lee, S.B. Berrisford, C.A. WakeWeld, T. Issioui, S.B. Jones and D.B. Jones. Comparison of acustimulation and ondansetron for the treatment of established

- postoperative nausea and vomiting. *Anesthesiology*. 97(6): 1387-1392, 2002.
- Ernst, E. and M.H. Pittler. The effectiveness of acupuncture in treating acute dental pain: A systematic review. *Br. Dent. J.* 184(9): 443-447, 1998.
- Greif, R., S. Laciny, M. Mokhtarani., A.G. Doufas, M. Bakhshandeh, L. Dorfer and D.I. Sessler. Transcutaneous electrical stimulation of an auricular acupuncture point decreases anesthetic requirement. *Anesthesiology*. 96(2): 306-312, 2002.
- Han, J.S. Acupuncture and endorphins. *Neurosci Lett* 361(1-3): 258–261, 2004.
- Itoh, K., H. Ochi and H. Kitakoji. Effects of tender point acupuncture on delayed onset muscle soreness (DOMS): A pragmatic trial. *Chin. Med.* 3:14, 2008.
- Knardahl, S., M. Elam, B. Olausson and B.G. Wallin. Sympathetic nerve activity after acupuncture in humans. *Pain*. 75(1): 19-25, 1998.
- Liang, F., D.L. Luo, Y.F. Hou and J. Zhang. Effect of acupuncture on the recovery of fatigue after strenuous exercise. *J. Beijing Univ. Phys. Educ.* 26(2): 192-194 [in Chinese], 2003.
- Lin, J. G., S.J. Ho and J.C. Lin. Effect of acupuncture on cardiopulmonary function. *Chin. Med. J.* 109(6): 482-485, 1996.
- Lin, J.G., H.S. Salahin and J.C. Lin. Investigation on the effects of ear acupressure on exercise-induced lactic acid levels and the implications for athletic training. *Am. J. Acupunct.* 23(4): 309-313, 1995.

- Lin, J.G. and W.L. Chen. Acupuncture analgesia: a review of its mechanisms of actions. *Am. J. Chin. Med.* 36(4): 635-645, 2008.
- Lin, Z.P., L.W. Lan, T.Y. He, T.C. Ma, F. Chia, J.G. Lin, J.J. Hsu, T.J. Ho. Effects of Acupuncture Stimulation on Recovery Ability for Male Elite Basketball Athletes. *Am. J. Chin. Med.* 37(3): 471-481, 2009.
- Manheimer, E., S. Wieland, E. Kimbrough, K. Cheng, and B.M. Berman. Evidence from the Cochrane collaboration for tradition Chinese medicine therapies. *J. Altern. Complement. Med.* 15(9): 1001-1014, 2009.
- Oleson, T.D., R.J. Kroening, and D.E. Bresler. An experimental evaluation of auricular diagnosis: The somatotopic mapping of musculoskeletal pain at ear acupuncture points. *Pain.* 8: 217-229, 1980.
- Qu, Z.Q., D.H. Lu and Y.R. Wang. Mechanism of acupuncture and effects on recovery of contractile force and ultrastructure in the exhausted muscles. *J. Beijing Inst. Phy. Educ.* 16(2): 35-44 [in Chinese], 1993.
- Sator-Katzenschlager, S.M., J.C. Szeles, G. Scharbert, A. Michalek-Sauberer, A. Kober, G. Heinze and S.A. Kozek-Langenecker. Electrical stimulation of auricular acupuncture points is more effective than conventional manual auricular acupuncture in chronic cervical pain: a pilot study. *Anesth Analg.* 97(5): 1469-1473, 2003.

- Sator-Katzenschlager, S.M., G. Scharbert, S.A. Kozek-Langenecker, J.C. Szelesm, G. Finster, A.W. Schiesser, G. Heinze and H.G. Kress. The short- and long-term benefit in chronic low back pain through adjuvant electrical versus manual auricular acupuncture. *Anesth Analg.* 98(5): 1359–1364, 2004.
- Ulett, G.A., S. Han and J.S. Han. Electroacupuncture: Mechanisms and clinical application. *Biol. Psychiatry.* 44(2): 129-138, 1998.
- Wang, W.Y., D. Niu, H. Wang, D.H. Chiu and Y.S. Hu. A clinical study on treating exercise-induced fatigue with acupuncture. *Chin. Acup. Moxi.* 1: 13-15 [in Chinese], 1999.
- White, P.F., T. Issioui, J. Hu, S.B. Jones, J.E. Coleman, J.P. Waddle, S.D. Markowitz, M. Coloma, A.R. Macaluso and C.H. Ing. Comparative efficacy of acustimulation (ReliefBand) versus ondansetron (Zofran) in combination with droperidol for preventing nausea and vomiting. *Anesthesiology.* 97(5): 1075-1081, 2002.
- White, P.F., M.A. Hamza, A. Recart, J.E. Coleman, A.R. Macaluso, L. Cox, O. Jaffer, D. Song and R. Rohrich. Optimal timing of acustimulation for antiemetic prophylaxis as an adjunct to ondansetron in patients undergoing plastic surgery. *Anesth. Analg.* 100(2): 367-372, 2005.

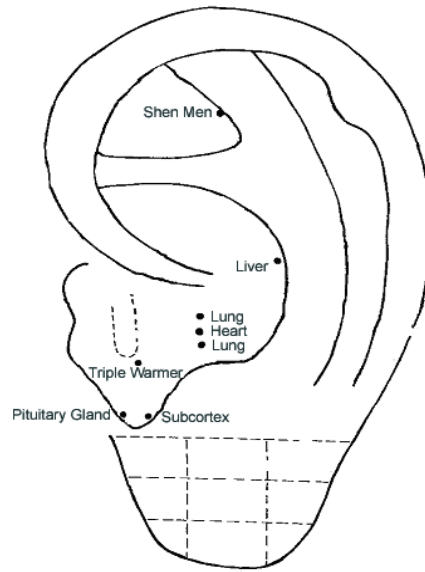


Figure 1. Distribution of simulative auricular acupoints

Table 1 Comparison of Cardiopulmonary Endurance between AAG and NCG

Variables	Auricular Acupuncture	Normal Control Group
	Group (AAG)	(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 statistically significant (p <0.05) when compared with NCG