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FOUR WEEKS OF ACUPUNCTURE DOES NOT ALTER NATURAL KILLER CELL RESPONSE TO EXERCISE

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ABSTRACT

Hutchison AT, Lewis DE, Bush JA, Strohacker K, Carpenter KC, McFarlin BK. Four weeks of acupuncture does not alter natural killer cell response to exercise. *JEPonline* 2008;11(5):42-50. Exercise may suppress natural killer cell activity (NKCA) for up to 24-h, creating an "open window" during which an individual may be more likely to get sick. Previous research has shown that acupuncture improves NKCA in animals and immuno-compromised humans. The purpose of the study was to determine whether 4wks of acupuncture could prevent post-exercise suppression of NKCA. Thirteen well-trained aerobic athletes were randomly assigned to either an acupuncture (ACU) or placebo (SHAM) group. All subjects completed two exercise sessions (60-min of cycling at 78% $\dot{V}O_{2peak}$): prior to and after 4-wks of ACU/SHAM. NK cell number ($CD3^+/56^+$) and activity ($CD69$ and $CD107a$) were quantified by flow cytometry before (PRE), immediately following (POST), and 2-h (2H) post exercise. Serum cortisol was determined by EIA. NK cell number, activity, and cortisol concentration were not altered by ACU. NK cell surface expression of $CD107a$ was higher in the ACU group following 4-wks of acupuncture treatments (5.48 vs. 3.65 MFI, $P = 0.022$), however, this effect was abolished by exercise. In conclusion, ACU may alter selective aspects of resting NKCA; however, it does not appear to protect against the suppressive effects of strenuous aerobic exercise.

Key Words: Immunity, NKCA, Exercise, Open Window, Flow Cytometry.

INTRODUCTION

Strenuous aerobic exercise has been reported to cause immunosuppression for up to 24-hours after exercise [1-4]. Post-exercise immunosuppression has been termed the “open window”, during which time pathogenic organisms can gain a foothold and cause infection, particularly to the upper respiratory tract (URTI) [1-4]. Immune responses during this period are primarily mediated by actions of the innate immune system. Previous investigations from our laboratory and others have demonstrated that the assessment of natural killer (NK) cells (count and activity) can be used as an appropriate index of innate immunity [5-9]. NK cells are large, granular lymphocytes of the innate immune system that function by eliminating cancerous cells and virally infected cells and by inhibiting the colonization of several types of pathogenic organisms including bacteria, viruses, and fungi [4, 10, 11]. NK cell function has been shown to decrease by as much as 60% following high intensity exercise and is considered a risk factor for increased illness in highly-trained aerobic athletes [5-9, 12].

The mechanism responsible for shifts in natural killer cell activity (NKCA) is not known; however, it has been speculated that disruptions in immune function may be mediated by cortisol, which are released in response to exercise [6,7,13]. This “stress hormone” functions by preparing the body for the extreme physical conditions experienced during high intensity exercise [14]. Cortisol is a glucocorticoid hormone produced in the adrenal cortex with widespread actions that help restore homeostasis after stress, particularly that caused by decreased blood glucose levels resulting from physical exertion and fasting [15-17]. It acts as a physiological antagonist to insulin by promoting gluconeogenesis, lipolysis, protein catabolism, and by mobilizing extrahepatic amino acids and ketone bodies [14-19]. This leads to increased blood glucose concentrations resulting in increased glycogen formation in the liver. The prolonged secretion of cortisol can result in a state of hyperglycemia. NK cells express cortisol receptors on their cell surface, and prolonged exposure results in a decrease in NKCA [21-23]. Despite the link between blood glucose and cortisol concentration, carbohydrate supplementation during exercise has not proven to be a reliable countermeasure to prevent post-exercise immunosuppression [6,24,25].

Although carbohydrate supplementation has not been conclusively established as an effective countermeasure against decrements in post-exercise NKCA, it is reasonable to speculate that attenuation of cortisol release may prevent post-exercise immunosuppression. Acupuncture has the potential to alter cortisol release and thus may be a potential countermeasure against post-exercise immunosuppression [26]. It also has been reported that acupuncture may directly improve immune function by stimulating the release of endogenous endorphins (natural opioids including β -endorphin and met-enkephalin) [27-29]. Leukocytes, including NK cells, have receptors for these endogenous endorphins that when bound, increase NKCA [27-30]. Others have reported that acupuncture increases NKCA in rodents and immuno-compromised adults [31-34]. To our knowledge, acupuncture has not been evaluated as a potential countermeasure against post-exercise immunosuppression.

Although there has been research on the effect of acupuncture on NKCA, these studies either utilized animal models or immuno-compromised humans during rest [31-34]. Thus the objective of the present study was to determine if acupuncture could improve NKCA in healthy, well-trained humans following a bout of acute, high-intensity exercise. We hypothesized that 4-wks (8 treatments) of acupuncture treatments would attenuate the post-exercise suppression of NKCA by altering the release of “stress hormones” during exercise.

METHODS

Subjects

All testing procedures were approved by the University of Houston's Committee for the Protection of Human Subjects (CPHS). Fourteen healthy male and female aerobically-trained individuals (18 to 45 yr) were recruited from local triathlon, running, and swimming clubs (Table 1). One subject dropped out once the study had begun. Prior to formal testing, the risks and benefits of participation were explained and each subject was asked to sign university approved informed consent and medical history forms. Individuals with asthma, cardiovascular disorders, known metabolic disorders, and regular consumers of non-steroidal anti-inflammatory medications were excluded because these conditions may influence the immune system. Individuals who used tobacco products or had more than a moderate intake of alcohol (>4 drinks/week) were also excluded because these substances may alter the observed immune system response. Participants were asked to log their weekly activity and to provide a record of their diet for the 24-h prior to each exercise testing session.

Table 1. Subject characteristics.

Characteristic	Mean	Range
SHAM Group (N = 7)		
Age, yr	31 ± 7	21 – 43
Height, cm	170.2 ± 9.2	157.5 – 182.9
Body mass, kg	65.2 ± 12.2	55.0 – 84.8
BMI (kg/m ²)	22.3 ± 1.9	19.5 – 25.3
Max HR (bpm)	180.1 ± 7.8	171 – 195
VO _{2peak} (mL·kg ⁻¹ ·min ⁻¹)	49.0 ± 4.6	42.1 – 56.7
ACU Group (N = 6)		
Age, yr	31 ± 8	20 – 43
Height, cm	172.9 ± 8.2	162.6 – 180.3
Body mass, kg	71.3 ± 14.3	55.0 – 88.6
BMI (kg/m ²)	23.6 ± 1.9	20.8 – 27.4
Max HR (bpm)	173.0 ± 7.8	160 – 188
VO _{2peak} (mL·kg ⁻¹ ·min ⁻¹)	46.6 ± 4.6	41.1 – 56.8

Note. One subject (ACU group) chose to withdraw prior to completion of the study.

Exercise Trial Conditions

Subjects completed two exercise trials with at least four weeks of either acupuncture (ACU) or placebo (SHAM) treatments between trials. Exercise trials were completed between 0600 and 1100 in a double-blinded design. The subjects were instructed to consume a normal mixed diet the day prior to each experimental trial. Exercise consisted of 60-min on an electrically braked cycle ergometer (Velotron Pro; Seattle, WA) at 75–80% VO_{2peak} (Vmax Metabolic Analyzer; Parvomedics; Salt Lake City, UT). Water (250 mL) was provided every 15-min until completion. Respiratory gases, heart rate, and RPE were measured at 0-5, 25-30, and 55-60 min of exercise to confirm that subjects were exercising within the target intensity zone. During recovery, water was provided *ad libitum*. Subjects were instructed not to consume additional food or beverages until after returning to the laboratory for the 2-h post-exercise blood sample.

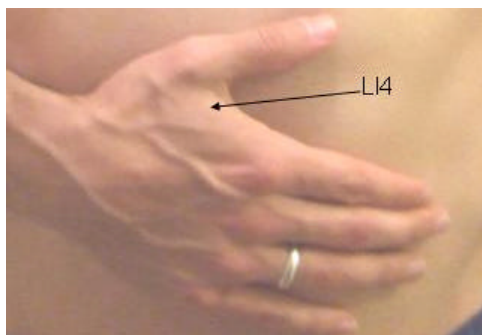


Figure 1. Acupoint LI4

Acupuncture Treatments

All acupuncture treatments were conducted at the American College of Acupuncture and Oriental Medicine (Houston, Texas) and carried out by interns from the College under the supervision of licensed acupuncturists. All acupuncture treatments were carried out as per the regulations established by the Texas State Board of Medical Examiners. All subjects were scheduled to receive eight acupuncture treatments, either actual (ACU) or placebo (SHAM), over the course of 4-wks. Acupuncture points were chosen with the aim of stimulating

control systems relevant to immunology and exercise performance [35].

The following classical acupuncture points were used: P6, Sp4, St36, Sp6, Lu7, Kd6, Liv3, and LI4 (Figures 1-3). Localization of the points at the extremities was accomplished with the aid of a cunometer and the position of each puncture located by careful palpation with the tip of the finger. Needling was carried out bilaterally with the depth of the puncture varying according to the anatomical circumstances from 1 mm to approximately 2 cm.

Pre-sterilized stainless steel needles (34 gauge; 1 inch) were used. The subjects lay supine during the 20-min treatment session. All subjects were blindfolded during the treatments sessions to prevent them from knowing their treatment condition (i.e., ACU vs. SHAM). Those in the SHAM group were pricked with toothpicks in the same locations as those in the ACU group, but the skin was not penetrated. To test the validity of the placebo method, three subjects not involved in the exercise trials underwent a combination of three toothpick pricks and three acupuncture needle insertions at different acupoints while wearing a blindfold. After each stimulation, the subjects were asked to determine if a toothpick or acupuncture needle had been used. Of the 18 total stimulations, only six (33%) were determined accurately, i.e. the subjects accurately guessed that a toothpick had been used or vice versa. This is well below that which would be expected to occur by chance alone (50%). Additionally, during the study only six of the 13 subjects were able to accurately determine which group they had been assigned to, i.e. SHAM or ACU. These results support the conclusion that the use of toothpicks is a reliable form of placebo to be used during acupuncture studies.

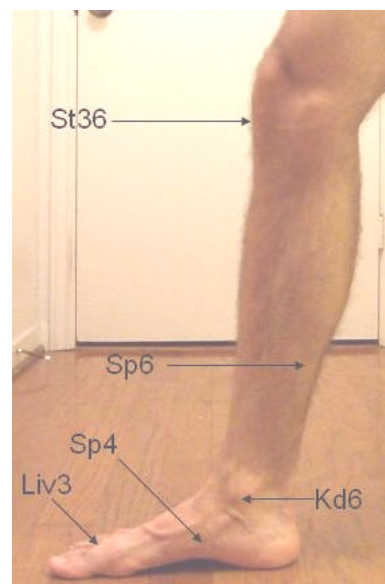


Figure 2. Acupoints St36, Sp4, Sp6, Liv3, Kd6



Figure 3. Lu7, P6

Blood Collection

Venous blood samples (20 mL) were collected from a peripheral arm vein into evacuated tubes (Vacutainer; Becton-Dickenson; Franklin Lakes, NJ) treated with either sodium heparin or a clotting factor (SST) to allow for serum separation: before exercise (PRE), immediately after exercise (POST), and at 2-h of recovery (2H). All blood samples with the exception of POST were taken following 15-min of seated rest. Sodium heparin treated blood was stored at room temperature on a rocker and processed within 1-h of collection for determination of leukocyte concentration, and cell-surface staining. The serum tubes were centrifuged within 60-min of collection to isolate serum, which was stored (-80°C) until measurement of cortisol levels by EIA. Both trials for each subject were completed within 1-h of the same time of day (start times were between 0600 and 1100) in order to minimize variation in serum cortisol concentration between conditions.

Total Leukocyte Concentration

To determine total leukocyte counts, whole blood (10 μ L) was added to 3% acetic acid (390 μ L) in a polystyrene tube and the solution was allowed to incubate for 30-s at room temperature. Triplicate total leukocyte counts were determined using a manual hemocytometer.

Flow Cytometry

Prior to the initiation of the experimental protocols, controls (positive and negative) were run on both unstimulated and stimulated (IL-15, a potent stimulator of NKCA) whole blood samples. Positive controls were used to establish compensation settings for the combination of fluorescent dyes to be used (FITC, PE, Pe-Cy5; BD-Bioscience; San Jose, CA) and (Alexa 647, eBioscience; San Diego, CA). Sodium heparin-treated whole blood (100 μ L) was combined with fluorescent-labelled antibodies to determine total NK cells (CD3⁻/CD56⁺), activated NK cells (CD3⁻/CD56⁺/CD69⁺), and degranulating NK cells (CD3⁻/CD56⁺/CD69⁺/CD107a⁺). Antibodies were used at manufacture titred concentrations. Whole blood samples were labelled for 15-min (in the dark at room temperature). The red blood cells were then lysed and the samples fixed using an automated method (TQ-Prep; Beckman Coulter; Fullerton, CA). The cells were stored in a refrigerator (~6°C) and analyzed within 12-h of labelling on a flow cytometer equipped with a 488 nm air-cooled argon laser (LSRII; Becton-Dickinson; Franklin Lakes, NJ). Primary gates were established for lymphocytes based on forward scatter and 90° side scatter. Secondary gates were established on total NK cells (CD3⁻/CD56⁺), activated NK cells (CD3⁻/CD56⁺/CD69⁺), and degranulating NK cells (CD3⁻/CD56⁺/CD69⁺/CD107a⁺).

Serum Cortisol Concentration

Serum concentrations of cortisol (Monobind Inc; Lake Forest, CA) were determined in duplicate using EIA. Controls (both commercially available and laboratory generated) were included with each batch of samples to determine the intra and inter-assay coefficients of variation, all of which were below 10%.

Statistical Analyses

A *Priori* sample size calculations were completed prior to the study using Gpower (v.2.0; Bonn, Germany). We utilized a study published by Bin *et al.* for the present effect size calculation because it was the most similar to our design [32]. Using this previously published data, we calculated a Cohen *d* of approximately 0.92, which translates to a large effect size (defined as > 0.80). Using this effect size, we calculated that in order to achieve 80% statistical power, a minimum of six sampling points per group (total *n* = 12) was required to detect a significant group difference in NKCA. In order to account for possible loss of subjects as a result of attrition, we recruited 14 total subjects, seven per group. When the study was complete, we had a total of 13 subjects.

After the data collection and analysis was complete, statistical analysis was completed by using SPSS v14.1 (SPSS, Chicago, IL). Assumptions of normality and constant variance were confirmed by using quantile-quantile and residual plots, respectively. All blood measurements were analyzed using a 2 (group: ACU and SHAM) x 2 (study time: baseline and post-intervention) x 3 (exercise time: PRE, POST, and 2H) factorial ANOVA with repeated measures on the second and third factors. Cardiovascular measurements were compared by using a 2 (group: ACU and SHAM) x 2 (study time: baseline and post-intervention) x 3 (exercise time: 0-5, 25-30, 55-60 min) factorial ANOVA with repeated measures on the second and third factors. Significance was set at *P*<0.05, and significant *P* values were adjusted by using the Huynh-Feldt correction factor to account for a repeated measures design. When significance was found, a Student's *t*-test with Bonferroni correction for multiple comparisons (*P*<0.05) was used to determine the location of significance. All values are presented as means \pm SE.

RESULTS

Cardiovascular Measurements

No significant main effects or interactions were found for VO₂ or heart rate before or after treatment, between groups, nor during exercise (sessions were of similar intensity).

Total Leukocyte Concentration

The total leukocyte concentration was significantly greater POST (106%) and 2H (81%) relative to the PRE (main effect for exercise time $F_{2,22} = 36.221$, $P < 0.001$, $\eta_p^2 = 0.77$, (Figure 4). No significant main effects for treatment or interactions were observed for total leukocyte count.

Total Natural Killer Cell Concentration

A main effect for exercise time was found for total NK cell concentration (Figure 5) where POST was significantly greater than PRE (229%) and 2H (466%) ($F_{2,22} = 47.760$, $P < 0.001$, $\eta_p^2 = 0.81$). No treatment main effect or interaction was found, and thus a similar effect occurred in both the ACU and SHAM groups. PRE was 72% greater than 2H (main effect for exercise time $F_{2,22} = 23.673$, $P < 0.001$, $\eta_p^2 = 0.68$). A significant exercise time x treatment interaction ($F_{2,22} = 5.595$, $P = 0.029$, $\eta_p^2 = 0.34$) was found for total NK cell concentration where SHAM-POST was greater than ACU-POST both before (103%) and after (76%) the 4-wk intervention period, indicating the groups were different at baseline.

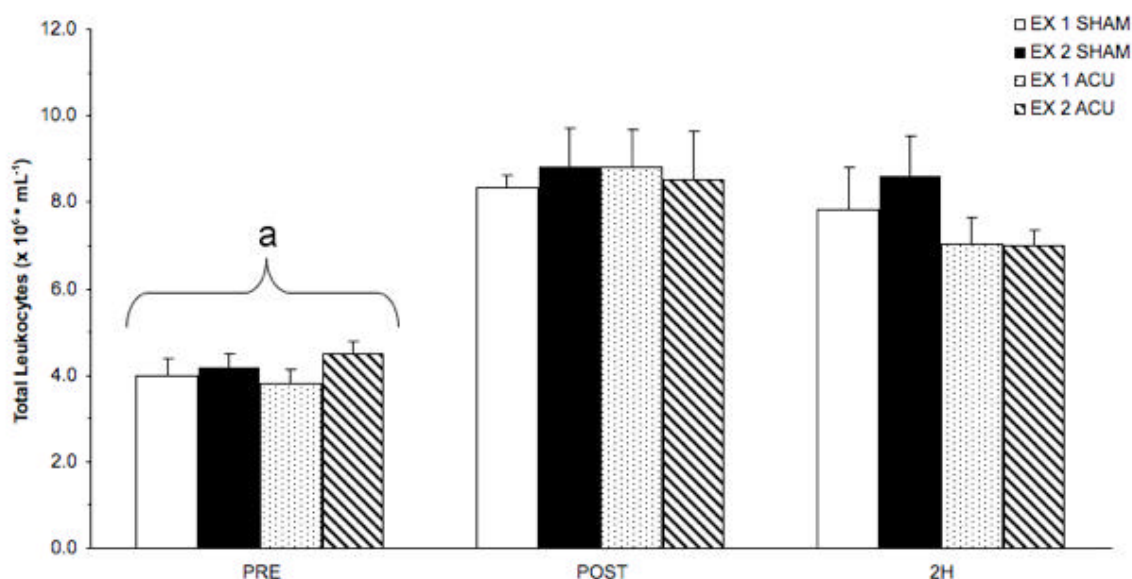


Figure 4. Total leukocyte concentration was determined by a manual method before (PRE), immediately after (POST), and at 2H of recovery from a 1-h bout of cycling at 78% VO_{2peak} . Exercise was completed prior to (EX1) and following (EX2) 4 wks of intervention of either real acupuncture (ACU) or placebo (SHAM). All values represent mean \pm SE. ^aindicates significantly less than POST and 2H (main effect for exercise time, $P < 0.001$).

Natural Killer Cell Activity

A main effect for exercise time was found for activated NK cell concentration (Figure 6) where POST was significantly greater than PRE (240%) and 2H (454%) (Main effect for exercise $F_{2,22} = 60.538$, $P < 0.001$, $\eta_p^2 = 0.85$). No treatment main effect or interaction was found, and thus a similar effect occurred in both the ACU and SHAM groups. Also, PRE was 63% greater than 2H (main effect for exercise time $F_{2,22} = 10.675$, $P = 0.008$, $\eta_p^2 = 0.49$). A significant exercise time x treatment interaction ($F_{2,22} = 11.877$, $P = 0.002$, $\eta_p^2 = 0.52$) was found for activated NK cell concentration where SHAM-POST was greater than ACU-POST both before (142%) and after (103%) the 4-wk intervention period, suggesting that the groups were different at baseline.

When collapsed across both treatment groups, the cell surface CD107a expression on activated NK cells was significantly greater (55%) following the four-week intervention period (main effect for study time $F_{1,11} = 131.597$, $P < 0.001$, $\eta_p^2 = 0.92$, (Figure 7). There was also an interaction effect (study time x group $F_{2,22} = 16.806$, $P = 0.002$, $\eta_p^2 = 0.60$) where the expression of CD107a was 18% greater in the ACU group than in the SHAM group following four weeks of acupuncture treatments. This was observed specifically at the PRE exercise time point following the 4-wk intervention period, where the cell surface expression of CD107a in the ACU group was significantly higher (50%) than that of the SHAM group ($F_{1,11} = 7.097$, $P = 0.022$, $\eta_p^2 = 0.39$).

Table 2. Serum cortisol response to 1-h of cycling (78% VO_{2peak}) before and after treatment with acupuncture (ACU) or placebo (SHAM).

Condition	Pre-Treatment			Post-Treatment		
	PRE	POST	2H	PRE	POST	2H
(nmol/L)						
SHAM	865.6 ± 116.5	1188.6 ± 130.8*	762.13 ± 104.5	863.3 ± 114.9	1050.3 ± 116.5*	625.7 ± 139.4
ACU	827.9 ± 86.6	1159.1 ± 35.2*	770.8 ± 118.2	702.9 ± 97.8	1144.2 ± 135.8*	643.9 ± 98.7

Values represent means ± SE.
* Indicate significantly greater than PRE and 2H (main effect for time $P < 0.001$).

Total Serum Cortisol

Serum cortisol concentration was significantly greater POST relative to the PRE (40%) and 2H (62%) (Main effect for exercise time $F_{2,22} = 25.588$, $P < 0.001$, $\eta_p^2 = 0.70$, Table 2). No significant main effects for treatment or interactions were observed for serum cortisol.

DISCUSSION

Contrary to our hypothesis, the findings of the current study indicate that 8 treatments) of acupuncture did not affect the circulating concentration of total NK cells ($CD3^+/56^+$) or activated ($CD3^+/56^+/69^+$) NK cells prior to or during recovery from high-intensity aerobic exercise.

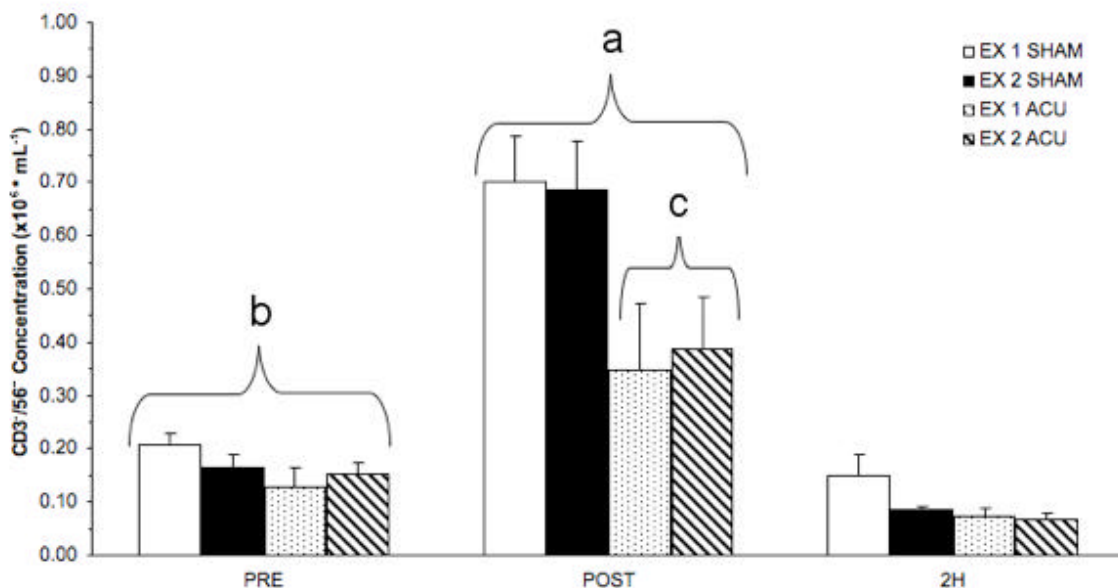


Figure 5. Total natural killer ($CD3^+/56^+$) cell concentration was determined by four-color flow cytometry before (PRE), immediately after (POST) and at 2H of recovery from a 1-h bout of cycling at 78% VO_{2peak} . Exercise was completed prior to (EX1) and following (EX2) 4 wks of intervention of either real acupuncture (ACU) or placebo (SHAM). All values represent mean ± SE. ^aindicates significantly greater than PRE and 2H (main effect for exercise time, $P < 0.001$). ^bindicates significantly greater than 2H (main effect for exercise time, $P < 0.001$). ^cindicates significantly less than SHAM-POST (interaction effect for exercise time *group assignment, $P = 0.029$).

Secondly, acupuncture treatments did not alter serum cortisol concentration at any time point before or after exercise. Acupuncture did increase the cell-surface expression of CD107a at rest; however, this increase was abolished by exercise.

Chronic acupuncture treatment did not alter the physiologic stress to exercise as measured by serum cortisol concentration. However, we did observe a 40% increase in the exercise response in serum cortisol concentration.

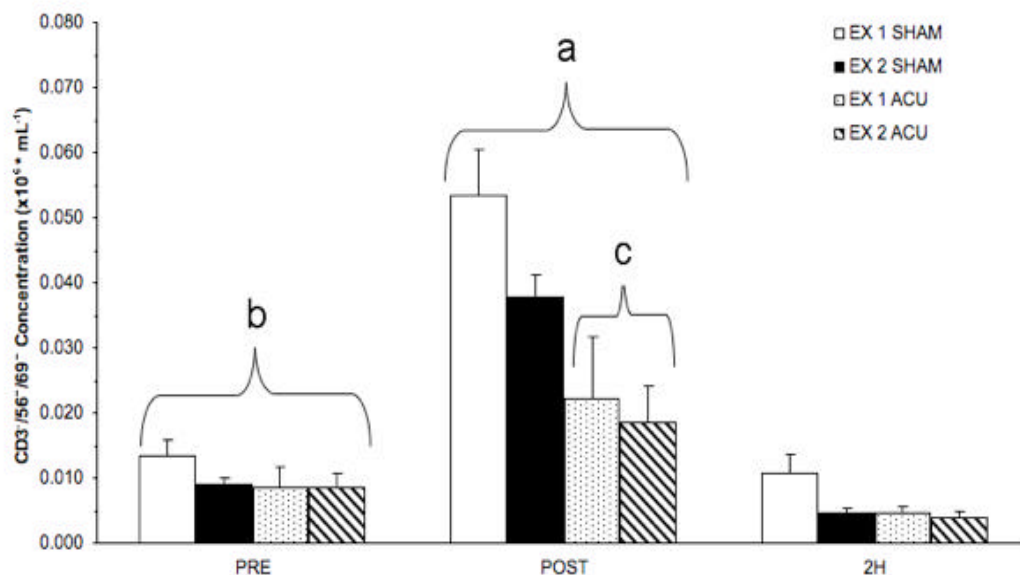


Figure 6. Activated natural killer (CD3/56⁺/69⁺) cell concentration was determined by four-color flow cytometry before (PRE), immediately after (POST) and at 2H of recovery from a 1-h bout of cycling at 78% VO_{2peak} . Exercise was completed prior to (EX1) and following (EX2) 4 wks of intervention of either real acupuncture (ACU) or placebo (SHAM). All values represent mean \pm SE. ^aindicates significantly greater than PRE and 2H (main effect for exercise time, $P < 0.001$). ^bindicates significantly greater than 2H (main effect for exercise time, $P = 0.008$). ^cindicates significantly less than SHAM-POST (interaction effect for exercise time *group assignment, $P = 0.002$).

This finding is consistent with the past research [6,7]. But, contrary to our results, Akimoto et al. (2003) who found acupuncture lowered the salivary cortisol concentration and perceived stress (i.e., as assessed by a profile of mood states questionnaire) in nine female soccer players following competition relative to a control group that received no treatment [26]. One major difference between the present study and that of Akimoto et al. was our use of a true placebo group, which may explain the difference in findings.

Serum cortisol concentration was measured because of its ability to directly inhibit NKCA by down-regulating the expression of cell-surface receptors responsible for triggering NK cell-mediated cytotoxicity (NKp46 and NKp30) *in vitro* [23]. According to the existing literature, carbohydrate supplementation is the most common countermeasure used during exercise to limit post exercise immunosuppression [6, 24, 25, 36]. The results of these studies have been equivocal. Niemen et al. determined that carbohydrate supplementation during 2.5-h of running at 77% VO_{2peak} decreased plasma cortisol and increased NK cell number but not NKCA [36]. Conversely, results from our laboratory suggest that carbohydrate supplementation during a 1-h (75-80% VO_{2peak}) cycling trial does not alter either plasma cortisol or unstimulated NKCA [6,7]. It is possible that our previous results and those of Nieman et al. differed because of differences in exercise duration. Our present findings are likely similar to our previous reports because the exercise duration was the same. In the present study we attempted to use acupuncture to mimic the effects that some groups have reported for carbohydrate supplementation; however, we did not find that acupuncture had this effect. It is possible that we did not find an effect of acupuncture on NK cell number and activity because serum cortisol (or some other unknown factor) was not altered by the treatment.

The primary finding of our present study is acupuncture therapy did not alter circulating concentrations of NK cells and activated NK cells. This finding appears inconsistent with existing literature on acupuncture-immune function [31, 32]. The likely explanation for the departures is related to differences in experimental design. Arranz et al. [31] reported

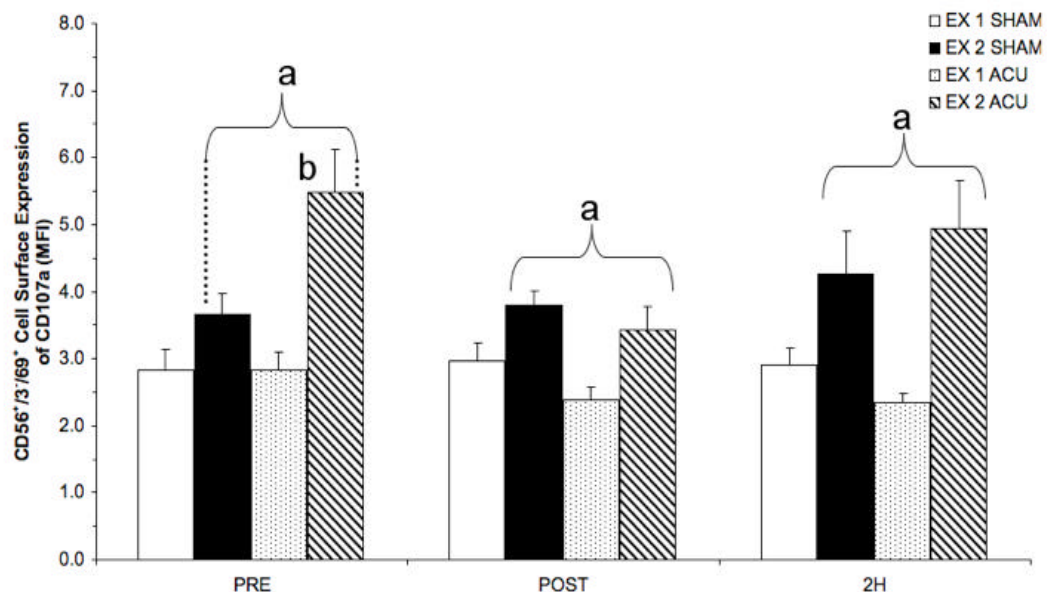


Figure 7. Cell surface expression of CD107a (LAMP-1) on activated natural killer cells (CD3⁺/56⁺/69⁺) was determined by four-color flow cytometry before (PRE), immediately after (POST) and at 2H of recovery from a 1-h bout of cycling at ~78% VO_{2peak} . Exercise was completed prior to (EX1) and following (EX2) 4 wks of intervention of either real acupuncture (ACU) or placebo (SHAM). All values represent mean \pm SE. ^aindicates significantly greater than EX1 (main effect for study time, $P < 0.001$). ^bindicates significantly greater than SHAM-PRE after 4-wk of intervention (EX2) (interaction effect exercise time, $P = 0.022$).

that acupuncture significantly increased cytolytic NKCA in a group of physically inactive women (30-60 y) suffering from chronic anxiety. Bin et al. [32] reported that cytolytic NKCA in cancer patients was significantly increased following chronic acupuncture treatment. Sato et al. and Kim et al. reported significant improvements in splenic NKCA in anesthetized rats following electroacupuncture at acupoint St36 [33,34]. It is really not possible to completely compare the key findings of our study to any of these previous works due to the extensive differences in subject populations and experimental design. To our knowledge, our study is the first to examine acupuncture as a countermeasure to strenuous aerobic exercise and under those conditions acupuncture therapy does not appear to be beneficial.

Despite the fact that acupuncture treatments did not alter the NK cell response to exercise nor serum cortisol concentration, we did find an increase in the expression of CD107a on activated NK cells at rest. CD107a is transiently expressed on the NK cell surface during degranulation [37, 38]. To our knowledge, this is the first study that has assessed CD107a as a marker of NKCA following acupuncture treatments. This secondary measure of NKCA may also be mediated in part by a physiological factor other than cortisol (i.e., endogenous endorphins) that does not directly affect the circulating concentration of NK cells or their activity as measured by cell-surface CD69 expression. The prevailing theory as to how acupuncture improves immune function, including that of NK cells, is by neuroendocrine modulation of the hypothalamic-pituitary-adrenal axis [39]. Following acupuncture, the pituitary gland releases endogenous endorphins that may then interact with cells of the immune system and modulate their function [39]. Specifically, lymphocytes have cell surface receptors for the endogenous endorphins, β -endorphin and met-enkephalin [28-30]. It is possible that the increased cell surface expression of CD107a following acupuncture was mediated by the release of endogenous endorphins that subsequently bound to NK cells.

Although the acupuncture protocol was determined from an examination of the relevant literature and consultation with experienced acupuncturists, it is possible that the lack of significant findings was a function of the duration, frequency, and location of acupuncture treatments and not the failure of the acupuncture itself. Future studies should attempt to standardize the treatment required to alter immune function following high-intensity exercise.

CONCLUSIONS

In conclusion, 4-wks (i.e., 8 treatments) of acupuncture were not effective in offsetting post-exercise immunosuppression as measured via changes in the traditional markers of NK cell concentration and activity. We did find a significant increase in NK cell expression of CD107a after chronic acupuncture treatment at rest; however, this increase was reversed during the exercise session. Acupuncture treatment did not alter serum cortisol concentration and interpretation suggests that the physiologic stress of exercise was not altered by acupuncture.

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