Effects of different recovery methods on postboxing sparring fatigue substances and stress hormones

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This study aimed to investigate the effects of static rest, massage, aromatherapy, and acupoint acupressure on the levels of fatigue substances and stress hormones produced after a session of boxing sparring. The study was conducted on female adolescent boxers (n = 12) who underwent four recovery methods with a 7-day rest period between each session. The order of these methods was decided randomly. Prior to each method, the participants performed five rounds of 4-min boxing sparring, and the maximal intensity was set as 70%–80% of the maximal heart rate. The effects of the four recovery methods on the blood levels of fatigue substances and stress hormones after boxing sparring were investigated. Static rest, massage, aromatherapy, and acupoint acupressure significantly decreased the lactic acid levels. The creatine phosphokinase levels decreased in the aromatherapy and acupoint acupressure groups, while the lactate dehydrogenase levels significantly decreased in the massage, aromatherapy, and acupoint acupressure groups. Further, the levels of stress hormones, cortisol, and epinephrine, showed no significant changes after massage and acupoint acupressure. However, a significant decrease in the cortisol level was observed in the aromatherapy group and an increasing trend was observed in the cortisol level in the static rest group. The adrenocorticotropic hormone level significantly decreased in the aromatherapy group and showed a decreasing trend after the participants received massage or acupoint acupressure. High-intensity exercise results in not only physical, but also psychological fatigue. Massage and aromatherapy can improve the physical and psychological stabilities and performances of athletes.

Keywords: Boxing sparring, Aromatherapy, Acupoint acupressure, Massage, Fatigue substance, Stress hormone

INTRODUCTION

As integration of science with sports is becoming more common, sports is approached from different perspectives to develop efficient training methods and identify ways to reduce fatigue and stress. Several sports investigators and coaches have become interested in effectively eliminating fatigue substances in the body and maximizing recovery from fatigue to improve sports performance.

The main reasons for postexercise fatigue are insufficient storage of nutrients, difficulty in neurotransmission, and accumulation of metabolites secondary to energy metabolism. Accumulation of lactic acid, which is produced by insufficient supply of oxygen during exercise, causes muscle fatigue and consequentially affects sports performance (Tesch, 1980). Creatine phosphokinase (CPK) and lactate dehydrogenase (LDH), which accumulate in the blood after prolonged or high-intensity exercises, are also important indicators of muscle fatigue (Banfi et al., 2009). Since outstanding recovery is directly related to sports performance, finding effective ways to remove fatigue substances and minimize changes in muscle damage markers, such as CPK and LDH, is markedly important (Cha et al., 2006; Rowsell et al., 2009).

Exercise exerts stress on the body, and the level of stress depends on the duration or intensity of the exercise. Disturbances in homeostasis due to exercise require a new level of adaptation that would activate the neuroendocrine response of the body. The sympathetic nerves and adrenal glands are especially important with respect to responsiveness to exercise stress. As the activity of the sympathetic nerves increases secondary to exercise, increased me-
Metabolism causes release of norepinephrine from the sympathetic fibers, which increases the respiratory rate. Epinephrine is released from the adrenal glands and has significant effects on metabolism (Christensen and Galbo, 1983). The blood cortisol levels are also increased following psychological/physiological stress. Exercise stimulates the release of adrenocorticotropic hormone (ACTH), which acts on the adrenal glands to stimulate cortisol production (O'Connor et al., 1989).

Alternative and complementary medicine strategies, including massage, electrical stimulation, ultrasonic wave, meridian, meditation, and aromatherapy, have been proposed to overcome exercise-induced fatigue and stress. Massage is a very important recovery or prevention method (Goats, 1994; Hemmings et al., 2000; Mori et al., 2004) and is used in diverse fields. The medical association is currently focusing on aromatherapy, in which aromatic scents travel through the olfactory system, skin, lungs, and circulation to reach the limbic system, where they stimulate the production of chemicals to improve the healing rate and reduce stress levels (Son et al., 2001).

In this study, alternative and complementary medicine strategies, including static rest, massage, aromatherapy, and acupoint acupressure, were used after high-intensity boxing sparring to reduce fatigue and stress. The condition of the participants was monitored using a heart rate monitor watch to maintain a maximal heart rate of 70%–80% (Table 2).

To minimize interaction among the different recovery methods (static rest, massage, aromatherapy, and acupoint acupressure), a 7-day break was provided for all participants. The recovery sessions were performed 20 min after the boxing sparring sessions. The order of the recovery methods was decided randomly, and the details are presented in Table 3.

Moreover, blood samples were collected from the participants immediately after the exercise and the recovery sessions. The blood was drawn by a nurse from the medical laboratory in Q Hospital from the participants’ cubital vein. The collected blood sample was centrifuged at 3,000 rpm for 30 min and stored at a -70°C fridge. All variable analyses were performed at the medical laboratory, and the participants’ lactic acid, CPK, LDH, cortisol, epinephrine, norepinephrine, and ACTH levels were measured.

All data analyses in this study were conducted using the IBM SPSS Statistics ver. 22.0 (IBM Co., Armonk, NY, USA). Means and standard deviations for all measurements were calculated, and repeated measures analysis of variance was performed to determine the significance of the different recovery methods. The significance level was set at 0.05.

**RESULTS**

Changes in the lactic acid level are presented in Table 4. Al-

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**Table 1.** Physical characteristics of the subjects (n = 12)

| Characteristic | Mean ± SD |
|---------------|-----------|
| Age (yr)      | 16.50 ± 1.00 |
| Height (cm)   | 165.33 ± 6.36 |
| Weight (kg)   | 53.58 ± 16.04 |
| Career (yr)   | 3.46 ± 0.58 |

SD, standard deviation.

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**Table 2.** Boxing sparring program

| Exercise | Intensity (maximal heart rate) | Program | Time (min) |
|----------|-------------------------------|---------|------------|
| Warm-up  | 40%–50%                       | Stretching | 15         |
| Sparring | 70%–80%                       | Five 4-min rounds (1-min break between rounds) | 24         |

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**Table 3.** Recovery methods

| Recovery type | Method |
|---------------|--------|
| Static rest   | 20 min of static rest while sitting in a comfortable position |
| Massage       | 20 min of massage by a masseuse while sitting on a chair to relax the muscles, progressing from the upper limbs and lower limbs to the lower back |
| Aromatherapy (rosemary) | 20 min of inhalation of essential oil while sitting |
| Acupoint acupuncture | 20 min of acupoint acupuncture performed by a specialist in the order of the upper limbs, lower limbs, and lower back |
though the interaction between the group and the time period was slightly higher than the significance level, it was determined to be present. Therefore, a paired sample t-test was performed in each group. The static rest, massage, aromatherapy, and acupoint acupressure groups showed a significant decrease in the lactate level from 204.70 ± 13.84 mg/dL postexercise to 570.24 ± 102.76 mg/dL postrecovery (P < 0.01), from 122.91 ± 11.25 mg/dL postexercise to 36.64 ± 6.82 mg/dL postrecovery (P < 0.01), and from 56.98 ± 22.60 mg/dL postexercise to 134.68 ± 92.43 mg/dL postrecovery (P < 0.01), respectively.

Changes in the creatine phosphokinase level are presented in Table 5. An interaction between the group and the time period was observed (P < 0.05). The static rest and massage groups did not show a significant change in the creatine phosphokinase level from 83.40 ± 16.34 U/L postexercise to 686.56 ± 174.38 nmol/L postrecovery (P = 0.03), respectively.

Changes in the lactic acid dehydrogenase level are presented in Table 6. An interaction between the group and the time period was observed (P < 0.05). The static rest and massage groups did not show a significant change in the lactic acid dehydrogenase level from 61.41 ± 18.94 mg/dL postexercise to 25.52 ± 22.72 pg/mL postexercise (P = 0.03). Changes in the cortisol level are presented in Table 7. An interaction between the group and the time period was observed (P < 0.05). The static rest group showed an increasing trend in the cortisol level from 572.59 ± 105.73 nmol/L postexercise to 510.14 ± 104.22 nmol/L postrecovery (P < 0.01), respectively. Changes in the epinephrine level are presented in Table 8. An interaction between the group and the time period was observed (P < 0.05). The static rest group did not show a significant change in the epinephrine level from 14.32 ± 6.27 pg/mL postexercise to 14.77 ± 5.94 pg/mL postrecovery (P = 0.03), respectively.

### Table 4. Changes in the lactate level (mg/dL) from postexercise to postrecovery in each group

| Group          | Postexercise | Postrecovery | F(P value) |
|----------------|--------------|--------------|------------|
| Static rest    | 50.91 ± 11.46 | 46.95 ± 12.21 | 17.83 (0.002) |
| Massage        | 61.41 ± 18.94 | 44.05 ± 8.70  | 17.99 (0.002) |
| Aromatherapy   | 50.82 ± 11.25 | 36.64 ± 6.82  | 20.09 (0.001) |
| Acupoint acupressure | 56.98 ± 22.60 | 38.29 ± 9.92  | 18.46 (0.002) |

Values are presented as mean ± standard deviation. $F_{group*time} = 4.29$ (0.052).

### Table 5. Changes in the creatine phosphokinase level (U/L) from postexercise to postrecovery in each group

| Group          | Postexercise | Postrecovery | F(P value) |
|----------------|--------------|--------------|------------|
| Static rest    | 83.40 ± 15.14 | 83.08 ± 16.34 | 0.35 (0.588) |
| Massage        | 122.91 ± 43.54 | 117.65 ± 38.31 | 1.28 (0.288) |
| Aromatherapy   | 83.31 ± 15.07 | 75.00 ± 15.56 | 24.22 (0.001) |
| Acupoint acupressure | 139.76 ± 90.43 | 134.68 ± 92.43 | 6.52 (0.031) |

Values are presented as mean ± standard deviation. $F_{group*time} = 5.48$ (0.03).
to 31.53 ± 25.82 pg/mL postrecovery, respectively. In contrast, the aromatherapy group showed a significant decrease in the epinephrine level from 13.58 ± 5.91 pg/mL postexercise to 8.44 ± 4.61 pg/mL postrecovery (P < 0.01).

Changes in the norepinephrine level are presented in Table 9. No interaction between the group and the time period was observed. Although no main effect in the time period was observed, significant difference among groups was observed.

Changes in the ACTH level are presented in Table 10. An interaction between the group and the time period was observed (P < 0.05). The static rest group did not show a significant change in the ACTH level from 3.45 ± 17.15 pg/mL postexercise to 35.65 ± 18.31 pg/mL postrecovery. In contrast, although the massage and acupoint acupressure groups showed a significant decrease in the ACTH level from 26.97 ± 14.03 pg/mL postexercise to 21.97 ± 8.25 pg/mL postrecovery and from 35.54 ± 22.86 pg/mL postexercise to 26.35 ± 12.21 pg/mL postrecovery, respectively, they both showed a decreasing trend. The aromatherapy group showed a significant decrease in the ACTH level from 32.45 ± 17.77 pg/mL postexercise to 24.48 ± 10.85 pg/mL postrecovery (P < 0.01).

**DISCUSSION**

The amount of lactic acid accumulation secondary to exercise depends on its intensity and duration. Lactic acid production is very high in high-intensity exercises (Tesch, 1980). Lactic acid is produced when there is decreased oxygen supply to the muscles, resulting in fatigue, which interferes with the ability to exercise. Therefore, it is important to develop or identify effective ways to remove fatigue substances.

Lactic acid accumulation in the body can be swiftly removed through light exercise or massage rather than rest (Belcastro and Bonen, 1975; Gisolfi et al., 1966; Hermansen and Vaage, 1977). Massage relaxes the muscles and improves oxygen supply to them, which leads to removal of lactic acid and its metabolites to improve muscle fatigue (Cafarelli and Flint, 1992; Callaghan, 1993). Although several studies have questioned the effects of massage on sports performance and fatigue substance removal, it was proven that massage has positive effects on recovery through psychological stabilization (Hemmings et al., 2000; Ogai et al., 2008; Robertson et al., 2004). Mori et al. (2004) also reported that massage improves circulation and body temperature after isometric exercise of the lower back.

In this study, all groups showed decreased postrecovery lactic acid levels compared with their postexercise levels. The largest decrease was observed in the aromatherapy group, followed by the acupoint acupressure, massage, and static rest groups. It seems that natural compounds or plant extracts inhaled to the lungs from aromatherapy would have maintained and facilitated physiological relaxation and psychological stabilization (Hemmings et al., 2000; Ogai et al., 2008; Robertson et al., 2004). Jeong et al. (2000) reported that aromatherapy shortens the recovery period by improving arm and leg pain through muscle relaxation. Furthermore, it was reported that aromatherapy improves sports performance. The acupoint acupressure technique involves exerting pressure on the acupoints of the hand, which have regulatory functions on the internal organs. Similar to massage, acupoint acupressure improves circulation and supply of oxygen to the muscles, leading to effective removal of lactic acid.

In this experiment, lactic acids were effectively removed even in

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**Table 8. Changes in the epinephrine level (pg/mL) from postexercise to postrecovery in each group**

| Group            | Postexercise | Postrecovery | F (P-value) |
|------------------|--------------|--------------|-------------|
| Static rest      | 14.32 ± 6.27 | 14.77 ± 5.94 | 0.56 (0.472) |
| Massage          | 33.16 ± 35.79 | 25.52 ± 22.72 | 2.73 (0.133) |
| Aromatherapy     | 13.58 ± 5.91 | 8.44 ± 4.71  | 10.88 (0.009) |
| Acupoint acupressure | 37.89 ± 32.76 | 31.53 ± 25.82 | 0.27 (0.619) |

Values are presented as mean ± standard deviation. $F_{(group \times time)} = 4.71 (0.042)$.

**Table 9. Changes in the norepinephrine level (pg/mL) from postexercise to postrecovery in each group**

| Group            | Postexercise | Postrecovery | F (P-value) |
|------------------|--------------|--------------|-------------|
| Static rest      | 256.21 ± 114.38 | 280.57 ± 119.91 | 5.11 (0.050) |
| Massage          | 225.89 ± 371.62 | 104.75 ± 87.65  | 1.05 (0.333) |
| Aromatherapy     | 218.54 ± 81.47 | 175.89 ± 86.34  | 1.50 (0.253) |
| Acupoint acupressure | 725.89 ± 628.65 | 371.65 ± 163.58 | 3.67 (0.088) |

Values are presented as mean ± standard deviation. $F_{(group \times time)} = 3.57 (0.075)$, $F_{(group)} = 5.37 (0.031)$, $F_{(time)} = 2.92 (0.122)$.

**Table 10. Changes in the adrenocorticotropic hormone level (pg/mL) from postexercise to postrecovery in each group**

| Group            | Postexercise | Postrecovery | F (P-value) |
|------------------|--------------|--------------|-------------|
| Static rest      | 34.45 ± 17.15 | 35.65 ± 18.31 | 2.51 (0.147) |
| Massage          | 26.97 ± 14.03 | 21.97 ± 8.25  | 4.01 (0.076) |
| Aromatherapy     | 32.45 ± 15.77 | 24.48 ± 10.85 | 17.67 (0.002) |
| Acupoint acupressure | 35.54 ± 22.86 | 26.35 ± 12.21 | 4.78 (0.057) |

Values are presented as mean ± standard deviation. $F_{(group \times time)} = 4.45 (0.048)$. 

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the static rest group. It is inferred that the athletes possessed an optimized lactic acid removal mechanism owing to adaptation of the cardiovascular system or muscles to constant exercise training.

CPK and LDH, blood metabolites along with lactic acid, are indirect indicators of cell membrane damage or tissue necrosis. The level of CPK, which is also a fatigue substance, rapidly increases in high-intensity exercises (Apple, 1981; Rich et al., 1977). Clarkson and Tremblay (1988) reported that postexercise muscle pain and decreased muscle strength are related to increased blood LDH and CPK levels, which are directly proportional to the severity of muscle damage. Since muscle fatigue and pain are influenced by blood CPK and LDH levels, rapid removal of these metabolites is very important for recovery from fatigue. Cha et al. (2006) analyzed changes in the CPK and LDH levels in different recovery methods after a 10-km run and reported that massage and aromatherapy were more effective than static rest in reducing fatigue. Although no significant changes were observed after static rest and massage, aromatherapy and acupoint acupressure significantly reduced the CPK levels. A significant decrease in the LDH levels was observed in the massage, aromatherapy, and acupoint acupressure groups postrecovery compared with those postexercise. Although the massage group did not show any changes in the CPK levels, the group that received acupuncture acupuncture, which is similar to massage, showed a significant decrease. It can be inferred that direct stimulation of the skin surface caused local vasodilation, which increased the blood supply to the muscles, consequently leading to the removal of CPK. Furthermore, massage, acupuncture acupuncture, and aromatherapy improved the recovery of the damaged muscles by rapidly removing LDH.

Excessive muscle fatigue due to high-intensity exercise with short rest intervals decreases the physiological adaptability of the body, and stress decreases muscle function and performance (Barr et al., 1991). Catecholamines, which are produced by the adrenal glands and sympathetic nerves, are closely related to exercise. Postexercise accumulation of lactic acid activates the chemical receptors that affect the hypothalamic-pituitary-adrenal axis (Stainsby et al., 1984).

In this study, a significant decrease in the cortisol, ACTH, and epinephrine levels was observed in the aromatherapy group compared with the postexercise levels. Aromatherapy stimulates the parasympathetic nerves and inhibits the activation of the sympathetic nerves. Furthermore, it stabilizes the autonomic nervous system’s balance. Therefore, aromatherapy is known to alleviate symptoms related to imbalance in the autonomic nervous system (Shin et al., 2004). With regard to the release mechanism of the stress hormone catecholamine, Langer (1980) reported that decreased stress and awakening were observed after simultaneously inhaling relaxation oil, which is made of lavender and clary sage known to reduce blood pressure and stress, and stimulation oil, which is made of lemon and rosemary. It can be inferred that inhaled aromatic oil scents affect the adrenal glands. Although the exact mechanism of aromatherapy has not been identified, a decrease in the stress hormone levels could result from chemical components in aroma, inducing physiological activity and stimulating the limbic system, which regulates the autonomic nervous system and emotions, when aromatic oil scents are inhaled and ultimately affect the hormonal system.

Although massage and acupuncture acupuncture showed a decreasing trend in the postrecovery ACTH levels compared with the postexercise levels, the epinephrine and cortisol levels were not altered significantly. The norepinephrine levels did not significantly differ between the groups. Although massage effectively relaxes the active sympathetic nerves, study results have not always been consistent. This can be because of the fact that massage is very broad in terms of location, duration, and personal sensitivity, and stress hormones are very sensitive to the environment and individuals’ physical and psychological differences.

The results showed that aromatherapy using essential oils was the most effective method in improving fatigue and reducing the stress hormone levels. Physical interventions, such as massage and acupuncture acupuncture, effectively improved stress and fatigue caused by muscle damage and pain.

In conclusion, further studies need to be conducted on a variety of recovery methods, which can approach the psychological and physiological aspects, rather than static rest only, when too much energy is used to the point of an anaerobic state in sports matches, and be applied to the field of sports and individuals’ daily life.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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