



Original Article

The effect of aroma stimulation during isotonic exercise on the rating of perceived exertion and blood fatigue factors of athletes with patellofemoral pain syndrome

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Abstract. [Purpose] The purpose of this study is to examine the effect of aroma stimulation during isotonic exercise on the rating of perceived exertion (RPE) and the blood fatigue factors of athletes who have patellofemoral pain syndrome (PFPS). [Subjects and Methods] The research subjects were seven athletes in their twenties who suffer from PFPS. They were divided into a control group and an aroma stimulation group and performed isotonic exercises repeatedly. After exercising, the RPE and blood fatigue factors, including creatine phosphokinase (CPK), lactate dehydrogenase (LDH), and ammonia, were measured through blood sampling. [Results] The aroma stimulus group showed significantly lower RPE than the control group immediately after exercising, which included leg presses, leg curls, bicep curls, and leg extensions. Among the blood fatigue factors, the change in LDH indicated the effect of aroma stimulation. [Conclusion] We confirmed that aroma stimulation during isotonic exercise has the positive effect of reducing the RPE and blood fatigue factors, such as blood LDH, of the athletes with PFPS.

Key words: Aroma stimulation, Isotonic exercise, Patellofemoral pain syndrome

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INTRODUCTION

Patellofemoral pain syndrome (PFPS) is accompanied by pain surrounding the kneecap. It is considered an excessive use syndrome and is frequently observed among athletes and women. Isotonic exercise is known to be effective for treating abnormal movement by strengthening lower limb muscles and correcting lower limb alignment¹⁻³).

The appropriate threshold of the load of isotonic exercise that reinforces muscle function in treating PFPS is approximately 40–60% of maximum muscle strength. If the equilibrium state that a body can endure is broken during isotonic exercise due to excessive burden, cells and tissues can be injured by oxidative stress. This in turn causes muscle fatigue and injury, which negatively impact the metabolism, the immune system, and the endocrine system⁴⁻⁶).

Aromatherapy is a type of supplementary treatment method that promotes the physical, psychological, and mental health of subjects by using therapeutic essential oils extracted from the flowers, leaves, stems, or roots of a variety of natural plants. The therapeutic effects of essential oils include relaxation, fatigue recovery, stress relief, and an immunity boost. Aroma stimulation has great significance in that the benefits of aromatic material can be directly delivered to the limbic system, which is responsible for the instinctive activity of human beings⁷). In terms of essential oils, rosemary stimulates circulation and relieves fluid retention, and peppermint is helpful for pain reduction and sedation⁸). The combination of two or three oils

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instead of using just one can maximize the effectiveness of aroma oil through the synergic effect⁹⁾.

We believe it is useful to apply aroma stimulation in clinical circumstances, such as when studying the isotonic exercise of athletes with PFPS, and to analyze the effects based on physiological variables. The purpose of this study is to determine the effect of aroma stimulation during isotonic exercise on the rating of perceived exertion (RPE) and blood fatigue factor of athletes with PFPS.

SUBJECTS AND METHODS

The study subjects were seven athletes diagnosed with PFPS upon a medical examination, a medical history check, and radiographic inspection at Hospital H located in City D, South Korea. The subjects were randomly divided into an aroma stimulus group and a control group, and their data were repeatedly measured. The average age of the subjects was 24.8 ± 2.06 years, their average height was 175.5 ± 4.03 cm, their average weight was 73.1 ± 3.8 kg, and their average body fat rate was $15.0 \pm 2.24\%$. The isotonic exercise program lasted for 80 min, and the intensity was set at 60% of one repetition maximum (1RM). Each set was composed of 7–9 exercise motions, and the subjects performed a total of three sets. A resting time of 1 min was allowed between each set. The main isotonic exercise for the lower limbs were leg presses, leg curls, and leg extensions. The order of the overall program was deadlift of lower back, leg presses after torso rotation, leg curls after pull down of shoulder and shoulder press, chest presses, bicep curls and triceps extension of upper limb, and leg extensions. For the aroma stimulation, a role-on insufflation scheme was used whereby the subjects lightly applied an aroma oil mixture consisting of lavender, rosemary, and peppermint in a ratio of 3:3:2 and jojoba oil on their wrist and inhaled the scent. The subjects rested comfortably for 60 s between each set during which time they inhaled the aroma. The RPE of each subject was measured right after completing each set of the isotonic exercise. The blood fatigue factors, including blood ammonia, CPK, and LDH, were analyzed after sampling blood before and after the application of the oil. We conducted a t-test on the measured data to examine the change in each group by time period and compared the change before and after the application using SPSS 21.0 for Windows. The significance level α was set at 0.05. This study has been prepared in accordance with the Namseoul University research ethics standards, and the subjects were safely protected throughout every stage of the experiment. All of the subjects understood the purpose of this study and provided written informed consent prior to their participation in accordance with the ethical standards of the Declaration of Helsinki.

RESULTS

Examining the change in RPE, the aroma stimulus group showed a significantly lower value than the control group right after doing the leg presses, leg curls, bicep curls, and leg extensions ($p < 0.05$). Examining the change in the blood fatigue factors, blood ammonia and blood CPK significantly increased in both groups after exercise. Although the blood LDH in the control group increased significantly after exercise, the aroma stimulus group did not show a significant change, indicating the effectiveness of aroma stimulation (Tables 1, 2).

Table 1. The comparison of RPE in each group

Group	Dead lift	Torso rotation	Leg press	Pull down	Shoulder press	Leg curl	Chest press	Biceps curl	Triceps extension	Leg extension
ASG (mean \pm SD)	14.0 \pm 1.3	12.0 \pm 1.6	12.4 \pm 0.9	13.4 \pm 1.3	14.0 \pm 1.4	12.4 \pm 0.7	13.4 \pm 1.2	13.1 \pm 1.3	14.1 \pm 2.1	13.0 \pm 1.0
CONG (mean \pm SD)	14.8 \pm 1.3	13.1 \pm 1.8	15.1 \pm 1.2	14.7 \pm 1.7	14.0 \pm 1.6	13.8 \pm 1.3	13.5 \pm 1.5	15.2 \pm 1.7	14.8 \pm 2.4	15.5 \pm 2.0
t-value	-1.21	-1.22	-4.60*	-1.49	0.00	-2.42*	-0.19	-2.52*	-0.57	-2.95*

* $p < 0.05$; ASG: aroma stimulation group; CONG: control group.

Table 2. The comparison of blood fatigue factors in each group

Group	Blood fatigue factors	Pre	After isotonic exercise
		(mean \pm SD)	(mean \pm SD)
ASG	LDH (U/l)	240.1 \pm 56.9	261.0 \pm 76.5
	CPK (U/l) *	178.7 \pm 49.3	205.2 \pm 65.5
	Amonia (umol/l) *	139.0 \pm 41.8	211.7 \pm 72.9
	LDH (U/l) *	221.57 \pm 56.3	291.6 \pm 82.4
CONG	CPK (U/l) *	168.7 \pm 73.1	197.7 \pm 96.0
	Amonia (umol/l) *	135.3 \pm 61.5	220.1 \pm 69.6

* $p < 0.05$; ASG: aroma stimulation group; CONG: control group.

DISCUSSION

Isotonic exercise by athletes with PFPS can produce a treatment effect as it strengthens muscle function if a certain amount is performed. However, a word of caution is in order as it can have a negative effect on physiological function; for example, muscle injury can occur if the intensity or amount of exercise exceeds a certain level⁵⁾. RPE is often used to assess the burden of an exercise program or amount of exercise on the human body^{10, 11)}. In general, RPE increases during isotonic exercise because lactic acid in muscles increases due to metabolic acidosis. Exercising under such circumstances can aggravate muscle fatigue or the level of difficulty. This stimulates the longitudinal section of the autonomous nerve inside muscles, eventually increasing the exercise stimulus¹²⁾. In our study, the aroma stimulus group showed a significantly lower RPE than the control group right after the leg press, leg curl, bicep curl, and leg extension exercises ($p < 0.05$). We must pay attention to the fact that the subjects of this study are athletes with PFPS and that RPE was significantly lower in the case of lower limb exercise.

Peppermint has a pain-reducing and sedative effect and helps keep the body and mind healthy. Lavender helps improve circulation to reduce muscle pain and neuralgia. Rosemary is known to be effective in promoting circulation and treating gout, rheumatism, and muscle fatigue due to its strong stimulating effect¹³⁾. We can say that the decrease in RPE after the aroma stimulation is related to the effectiveness of the oils. Oil that is inhaled through the nose during aroma stimulation has a physiological effect, as it acts on the limbic system through the olfactory epithelium of the nose. In particular, lavender is known to have sedative scent that diminishes activation level of sympathetic nerve to relieve anxiety, stress, and fatigue¹⁴⁾. Blood fatigue factors, including LDH and CPK, are indirect indicators of muscle injury, such as membrane destruction and tissue necrosis, in high-intensity exercise. They are also related to muscle pain after exercise and decreased muscle strength¹⁴⁾. Ammonia induces the creation of lactic acid and the rapid decrease of glycogen, resulting in muscle fatigue¹⁵⁾. Regarding the change in blood fatigue factors in our study, only the blood LDH indicated the effectiveness of aroma stimulation. The inhaled scent during aroma stimulation is converted to an electric signal after being detected by olfactory receptors. The signal then arrives at the prefrontal cortex and lifts the mood and decreases heart beat to reduce muscle tension¹⁶⁾. Lavender is effective for controlling stress and blood pressure, as it soothes nerve tissue by inducing harmony between the sympathetic nerve system and the parasympathetic nerve system. Peppermint is effective for reducing muscle pain and fatigue and boosting immunity with its particular blood and lymph affinity¹⁶⁾. Aroma stimulation is also reported to control the secretion of the stress hormone cortisol and to induce calmness and muscle relaxation by stimulating the stressed part, including the pituitary gland, the thyroid, the parathyroid, and the adrenal gland¹⁷⁾. It also helps reduce stimulation of the longitudinal section of autonomic nerves and myocytes¹⁸⁾. The results of our study confirm that aroma stimulation can have a positive impact in clinical circumstances, such as the performance of isotonic exercises by athletes with PFPS, by reducing RPE and blood fatigue factors, such as blood LDH, due to the effective properties of the oil. We believe that our study will contribute to the useful application of aroma stimulation in clinical situations.

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