Original article

Efficacy of topical *plai* (*Zingiber Cassumunar*) cream extract for symptomatic relief of delayed onset muscle soreness

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Objective To evaluate the efficacy of topical application of *plai* cream for symptomatic relief of delayed onset muscle soreness.

Study design An experimental double-blind randomized controlled trial of a novel method of symptom relief from delayed onset muscle soreness (DOMS).

Setting Suandok Fitness Center, Faculty of Medicine, Chiang Mai University

Methods Strenuous biceps curl exercise was used to induce DOMS in the biceps of the non-dominant arm of 30 healthy subjects. The DOMS symptoms appeared within 24 hours following exercise. The subjects were then randomly divided into 2 groups: an experimental (*plai*) group and a control (placebo) group. All subjects in each group were given a tube of cream to apply to their affected arms. The subjects in the experimental group were given *plai* cream while the subjects in the control group were given a *plai*-scented placebo cream with no anti-inflammatory ingredients. Pain measurements were made by blinded assessors using the Numeric Rating Scale (NRS) for clinical pain and the Pressure Pain Threshold (PPT) immediately after exercise, at 24-hours after exercise (when first use of the cream was prescribed), and at 72-hours after exercise.

Results Both the experimental and the control group showed a significant decrease in NRS compared to baseline. However, the experimental group had a significantly greater NRS reduction compared to the control group (3.73±1.53 vs 2.13±1.92, p=0.027). In addition, significant increases in PPT were observed in the experimental group, whereas no significant change in PPT was observed in the control group.

Conclusions The results indicated that *plai* cream might be superior to placebo cream for symptomatic relief from DOMS. **Chiang Mai Medical Journal 2017;56(2):69-79.**

Keywords: *plai* cream, delayed onset muscle soreness (DOMS), biceps, pain pressure threshold

Introduction

Exercise-induced muscle pain often discourages people who have just begun exercising from continuing, and hence is a major obstacle in making exercising a habit. This is especially troublesome for whom exercise is a part of their physiotherapy process. Muscle pains include muscle cramp, acute muscle strain, and delayed-onset muscle soreness (DOMS)-

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a symptom Theodore Hough discovered in 1902. DOMS usually occurs 12 to 24 hours after exercise, and is often found in amateur sports players or in people who try a new type of exercise. DOMS is often associated with eccentric exercise (1-3), and is a symptom that typically subsides on its own within a week.

Multiple studies have investigated the effectiveness of different DOMS treatments, e.g., muscle stretching, massaging, physical modalities such as ultrasound, cryotherapy, and ice massage, and non-steroidal anti-inflammatory drugs (NSAIDs) (4). However, study results have been mixed, so the effectiveness of these treatments is still inconclusive.

We are interested in further investigation of the effectiveness of DOMS treatment through application of *plai*-based medicine, particularly *plai* cream. This treatment alternative is inexpensive and readily available in Thailand, where *plai* is in great supply. *Plai* cream is inexpensively manufactured locally in large quantities.

Plai (*Zingiber cassumunar* ROXB.) is listed in the 2011Thai National List of Herbal Medicines in the category which includes anti-inflammatory drugs externally applied to treat bruises and swellings. There are two methods of extracting the active ingredients from fresh *plai* to create *plai* cream: vapor extraction (the traditional method) and hot-oil extraction. According to the 2011 List of Herbal Medicinal Products, the *plai* extraction method should be effective to certain extent to ensure the level of the active ingredient obtained is sufficient to be used in treatment. The List of Herbal Medicinal Products specifically mentions that the level of active ingredient obtained should be sufficient for use in treatment. Vapor extraction should yield at least 14% active ingredient, while effective hot-oil extraction should yield at least 90% active ingredient (5).

Studies have shown that if extraction from fresh *plai* is done using methanol, ether, and hexane, the resulting extract, when tested using the Thin Layer Chromatography (TLC) methodcontains 4 active compounds. These include (E)-4-(3,4–dimethoxyphenyl) but-3-en-1-ol (compound D), (E)-1-(3, 4-dimethoxyphenyl) but-1, 3-diene (DMPBD) and zerumbone. Researchers have conducted studies in rats to analyze the anti-inflammatory property of these compounds by investigating if either one of these any one of these four compounds can either alleviate inflammation in rats treated with carrageenan or reduce the permeability of the blood vessels resulting from stimulation by acetic acid. Results of these studies have shown that compound D has the greatest anti-inflammatory property (6, 7). Another study demonstrated that DMPBD has an anti-inflammatory effect both in vitro and in vivo (8). Subsequent studies have shown that active compounds in *plai* can inhibit cyclooxygenase (COX) and lipoxygenase (LOX). Release of COX and LOX leads to an increase of intermediate molecules, e.g., prostaglandins and leukotrienes, which, in turn, leads to inflammation. Thus by inhibiting COX and LOX, the compounds in *plai* can help reduce inflammation (9).

With the vapor extraction method, it is possible to obtain small, evaporable active compounds. However, with the hot-oil extraction method it is possible to obtain not onlysmall, evaporable anti-inflammatory compounds but alsolarge, non-evaporable anti-inflammatory compounds, e.g., arylbutanoids, curcuminoids, and cyclohexane derivatives) (10).

According to the studies mentioned above, *plai* has an anti-inflammatory property. However, no studies have been conducted to analyze the effect of *plai* on DOMS. If *plai*-based medicine, in particular *plai* cream, were demonstrated to be an effective treatment for DOMS, medical practitioners, especially those in Thailand, would have an additional good option for DOMS treatment.

Methods

The study population consisted of 30 male subjects. As menstruation can unpredictably affect exercise performance (11), females were excluded. Inclusion criteria were: 1) at least 17 years of age, 2) able to communicate fluently in Thai, 3) no participation in heavy resistance training within the previous 6 months, 4) no neuromuscular diseases or injuries in both upper limbs and no sensory deficit anywhere in the body, 5) no cardiopulmonary diseases that would preclude resistance exercises, and 6) willingness to sign the

voluntary participation consent form. Exclusion criteria included: 1) having taken any painkillers, muscle relaxants, or nutritional supplements 1 week prior to or after the resistance training session, 2) inability to complete the resistance training routine or inability to induce DOMS as measured by the experimental standard, 3) severe muscular pain or symptoms of acute muscle strain during or after the experimental session, 4) having received massage or other therapy on the muscle affected by the resistance training and 5) inability to induce MS which meets the following criteria:

- Pain with a numeric rating scale (NRS) score greater than 3.5 at 24-hours post exercise
- Increasing pain over time with delayed maximal intensity more than 8 hours after induction
- NRS increase over baseline (0) to greater than 3 at 24-hours post exercise.

Experimental equipment and tools

1. Dumbbells of various weights, ranging from 2 to 40 kilograms
2. An adjustable weight-training bench allowing a posture where the elbow can be extended from a 90-degree angle to a full stretch
3. A pressure algometer to record the pain pressure threshold (PPT)
4. Weighing scale
5. Stopwatch
6. Numeric rating scale (NRS) evaluation forms

Preparation of the *plai* cream and the placebo cream

To obtain the 100 grams of *plai* cream used in the experiment, we mixed 30 grams of *plai* oil with a cream base (which did not contain methyl salicylate). The placebo cream was made by mixing *plai* scent with the same cream base. Coloring was added to the placebo to make it look like the *plai* cream (Figure 4). We conducted chemical tests to verify that the placebo cream did not contain any active ingredient.

The *plai* cream was loaded into 30 tubes: 10 were labeled “A”, 10 “D”, and 10 “E”. The placebo cream was also loaded into 30 tubes:10 were labeled “B”, 10 “C”, and 10 “F” (Figure 1). The contents of the tubes were not known to the test subjects or to the experimenters.

Experimental procedures (diagram)

Research assistants recruited subjects who were eligible to participate in the experiment based on the inclusion and exclusion criteria. The research assistants then read the instructions to the subject and answers

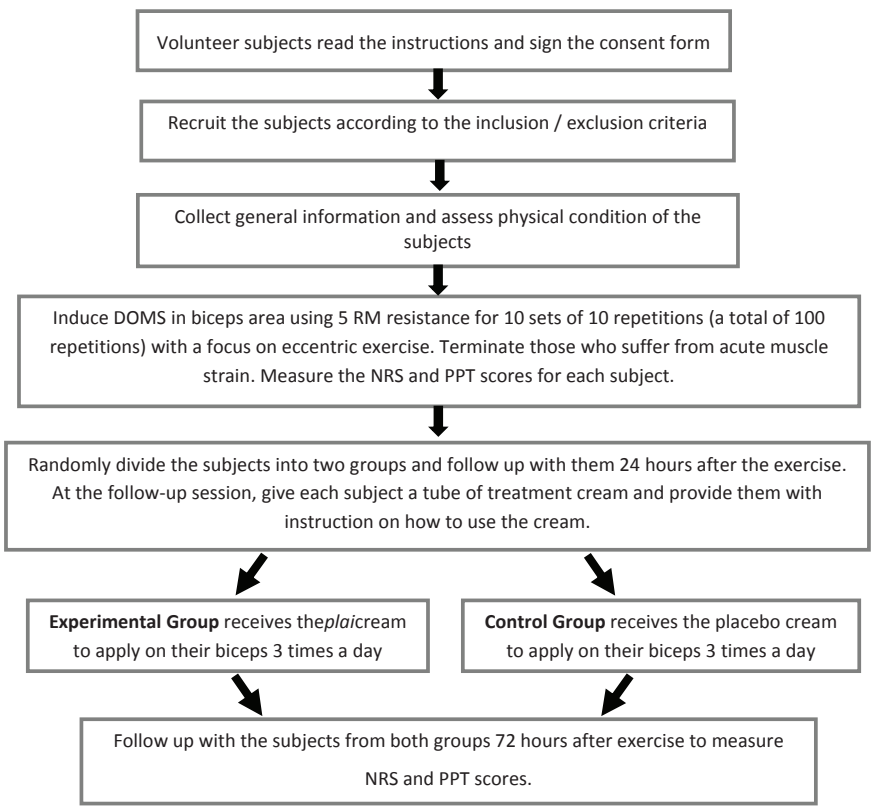

Figure 1. Labeled placebo and *plai* cream tubes

Figure 2. A researcher applying the pressure algometer on the non-dominant biceps of a test subject.

any questions they had. The subjects then signed an Informed Consent form before participating in the experimental session. The research assistants collect basic information from the subjects.

Researchers induced a DOMS condition in the subjects using methods described by Robbin et al.(12-14). Those methods included the following:

Determining the 5 Repetition Maximum (RM) of elbow flexors in the non-dominant arm for each test subject. The dumbbell weight assigned to that subject would be 110% of RM. The test subject were sitting on a chair with their elbows at a 90 degree angle.

The volunteers were then asked to perform the dumbbell curls with their hand in a supine position, decrease the elbow angle from 90 degrees to 0 degrees. That motion was slowly completed over 4 seconds. That was followed by a 3 second eccentric contraction during which the subjects extended the elbow back to the 90 degree angle. The researcher assisted the subject by supporting part of the dumbbell weight when the subject could not extend his elbow back to the starting position by himself. The elbow curl was be performed in sets of 10, with 10 sets per session (a total of 100 repetitions). The subject was given a 1 minute break between each set.

Each time a subject could not make the extension motion last 4 seconds, the dumbbell weight was reduced by 2 kg to ensure that the weight was sufficient to induce DOMS but not enough to result in more serious injury. All experimental sessions were supervised by a certified physician who was ready to immediately terminate a session if the subject developed acute muscle strain in order to prevent further injury. Subjects who developed acute muscle strain were treated with an acute pain killer and their condition was followed up.

Following the weight-training session, the researcher slowly applied pressure on the middle of the subject's biceps while the subject had his arm fully extended (Figure 2). The pressure was slowly increased until the subject perceived pain. This process was repeated 3 times. The level of pain each subject perceived at a given level of pressure as measured by an algometer was recorded as NRS and PPT scores. We then took the average for each measurement. Prior to the experiment, the researcher who recorded the NRS and PPT had administered the same measurement protocol at different times of the day on a subject who had not exercised and who was not included in the study. He found that the measurement results were not significantly different among these subjects. The researcher then repeated the same protocol on 4 additional subjects and obtained the same results, demonstrating that the researcher and the protocol had an acceptable level of consistency. Any subject who experienced acute muscle strain or who could not complete

Figure 3. Left: 100 grams of *plai* cream containing 30 grams of *plai* oil (obtained through hot oil extraction) and 70 grams of cream base. Right: 100 grams of placebo cream made from mixing *plai* scent with 100 grams of the same cream base used in creating the *plai* cream

the experimental protocol was to be terminated from the experiment and his data not recorded.

We followed up with all 30 subjects who had completed the exercise process, assessing their condition 24 hours after the weight-training session. We did not meet with all the subjects at once, but asked them to come in groups of 4 to 8 at which time they were given a tube of cream to apply to their muscles. Subjects whom we had assessed as experiencing DOMS (in our experiment, all the participants) were randomly divided into two groups using a computer random number generating system. The first group received the *plai* cream (tubes labeled "A" or "D"). The second group received the placebo cream (tubes labeled "B" or "C"). The subjects were told to apply the cream ad libitum 3 times per day to the affected area: in the morning, at noon, and in the evening. The research team demonstrated to the subjects how to apply the cream in an appropriate quantity and without massaging. This entire process was conducted in a double-blind randomized control trial manner, i.e., none of the subjects or the researchers who gave the subjects the treatment cream were aware of the cream production process and did not know which subjects receive the *plai* cream and which the placebo cream.

We followed up on the subjects' condition 48 hours after providing the treatment cream (72 hours after the weight-training session). During that follow-up session, we again recorded the subjects' NRS and PPT pain perception scores.

Important notes on the experiment

The subjects who completed 100 repetitions of the biceps curl should not have experienced considerable muscle pain immediately after the weight-training session, but they should experience much greater pain 24 hours after the session. An increase in NRS score of 3 or more after 24 hours indicated that the weight-training session had induced DOMS in the subject.

Research hypothesis

Treatment with *plai* cream made with *plai* hot-oil extract can reduce pain from DOMS significantly better than a treatment with a placebo.

Statistical analysis

Comparison of NRS score differences between the *plai* cream group and the placebo cream group was done using the Mann Whitney U test as the NRS data were not normally distributed ($p<.005$, using Kolmogorov-Smirnova). In the case of PPT scores, differences between the groups was done using the t-test as the PPT data were normally distributed. Differences between NRS scores before and after cream treatment were analyzed using the Wilcoxon signed rank test. Differences between PPT scores before and after cream treatment were evaluated using the paired sample t-test. All statistical analyses were done using SPSS version 22.0. Statistical significance was set at $p\geq0.05$).

Population sample size

Due to the lack of references to calculate the appropriate population size, we conducted this research as a pilot study using a sample size of 30.The study was approved by the Research Ethics Committee of the Medical Faculty of Chiang Mai University (Reference no. REH-2557-02116/ Study code REH-2557-02116).

Results

Thirty healthy male volunteer subjects underwent the weight-training session following the protocol described above and all experienced DOMS. The change in NRS scores 24 hours after weight-training were all greater than 3 (Table 1).

The subjects were randomly divided into 2 groups. The group that received the *plai*

Table 1. Demographic data and baseline NRS.

Characteristic	*Plai* group (15)	Placebo group (15)	*P-value*
Age	28.53±7.5	29.8±8.8	0.677*
Body weight	69.8±10.3	61.8±9.8	0.039*
Height	166.8±4.47	167.13±5.6	0.860*
Weight lifted for 100 repetitions	1179.6±207.5	1164.2±193.6	0.836*
DOMS after exercise			
NRS diff.> 3 at 0 and 24 hours	4.46±0.91	4.66±1.04	0.624†

†,Wilcoxon signed rank test for within group analysis; *p-value* is significant.

*,Mann-Whitney Test for between group analysis; *p-value* is significant; diff.=difference

Table 2. Average NRS scores of subjects receiving plai cream and subjects receiving placebo cream at 24 hours and 72 hours after weight-training session.

Measure		Intervention		Mean between group difference *p-value*
		Plai	Placebo	
NRS post exercise	24 hours (I)	5.2±1.146	5.13±0.99	
	72 hours (II)	1.47±0.834	3±1.927	
	I-II (diff.)	3.73±1.534	2.13±1.922	
	I-II (diff.) mean rank	18.97	12.03	
	P-value I-II (diff.)	0.001†	0.003†	0.027*

†,Wilcoxon signed rank test for within group analysis; *p-value* is significant.
*,Mann-Whitney Test for between group analysis; *p-value* is significant; diff.=difference

Table 3. Average *Pain* Pressure Threshold scores (kg.) of subjects receiving *plai* cream and placebo cream at 24 hours and 72 hours after weight-training session.

Measure		Intervention		Mean between group difference *p-value*
		Plai	Placebo	
PPT post exercise	24 hours (I)	2.69±1.03	2.77±0.98	
	72 hours (II)	3.29±1.03	3.14±0.83	
	I-II (diff.)	-0.596±0.84	-0.374±0.84	
	P-value I-II (diff.)	0.017†	0.107	0.447*

†, Paired t-test for within group analysis; *p-value* is significant.
*,Independent t-test for between group analysis; *p-value* e is significant.
diff.=difference PPT= pain pressure threshold

cream had a 4.46±0.91 increase in average NRS score at 24 hours while the group that received the placebo cream had a 4.66±1.04 increase in average NRS score. The difference between the two groups was not significant ($p = 0.624$). At the follow-up session conducted 48 hours after the weight-training, interviews with the subjects found that all had followed our instructions, so the data from all of them were included in our analysis.

Comparison of treatment results within groups (Tables 2 and 3, Figures 5-8) found that 48 hours after the weight-training session the NRS scores (level of pain perceived) in the group receiving *plai* cream had decreased by an average of 3.73±1.534 (p=0.001) while the average PPT score change, indicating a higher resistance to pain, was -0.596±0.84 kg (p=0.017). In the placebo cream group, the NRS scores had significantly decreased by an average of 2.13±1.922 (p=0.003) and the PPT scores declined by an average of 0.374±0.84 kg. which was not significant (p=0.107).

Comparison of results between groups (Tables 2 and 3, Figures 5-8) at 24 hours and at 72 hours after the weight training session found that the group that had received the *plai* cream treatment had a mean rank of 18.97 and the placebo treatment group had a mean rank of 12.03. This indicates that the *plai* treatment reduced pain significantly better than the placebo treatment (p=0.027). Comparison of difference in PPT scores between the two groups at 24 hours and 72 hours after the weight training session found no significant difference (0.22±0.30, p=0.447).

In terms of volume of cream used, the *plai* cream group used significantly less of the cream than the placebo cream group (6.56± 3.66 vs 11.90±6.16 gram, p=0.008), another indication of the relative effectiveness of the *plai* cream.

Side effects of cream treatment

No side effects from the cream treatment, e.g. rash or contact dermatitis (15), were

observed by the researchers or reported by any of the 30 subjects.

Discussion

Studies have shown that DOMS is an indirect muscle injury and is correlated with eccentric overload and high intensity exercises (1, 2,16). These two types of exercises can trigger multiple chain reactions in the body system which lead to DOMS (17-19). Eccentric exercise can cause damage the muscle fiber around the Z-line. This type of damage can also disrupt the actin-myosin structure before the muscle relaxes. The effect on the actin-myosin structure leads to higher stress in the muscle cells. That higher stress has three consequences. First, the pain receptors in the muscle fibers become more sensitive to microtrauma, and hence the subject could experience pain more easily (1-2). Second, the body system releases compounds into the blood stream which are specifically involved in muscular inflammation, including creatine kinase, myoglobin, and troponin. Third, the resulting increase in osmotic pressure leads to higher concentrations of fluid in the muscle fibers involved in the exercise. This affects calcium regulation in cells, and hence leads to higher intracellular calcium concentration, which, in turns, leads to sensation of pain.

The inflammation in the muscle fibers from the damage leads to multiple changes in the body including an increase in vascular permeability and higher levels of inflammation-inducing intermediate compounds, e.g., prostaglandins, leukotrienes, histamine, and serotonin, which are triggered by the release of LOX and COX enzymes (3). These effects collectively make the subject experiencing DOMS start to feel pain beginning about 12 hours after exercise.

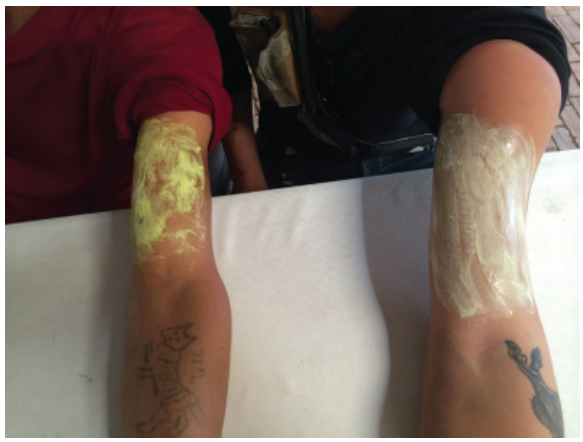

Figure 4. *Plai* cream was applied on the subject on the left side, while placebo cream was applied on the subject on the right side.

Plai-based cream is one of the treatment alternatives for DOMS. We focused this study on *plai* cream made from hot-oil extract since we believe that the active ingredients present in the cream would be higher than in *plai* cream made using the traditional *plai* oil extraction method. We are not aware of any study which has used *plai* cream made by hot-oil extraction

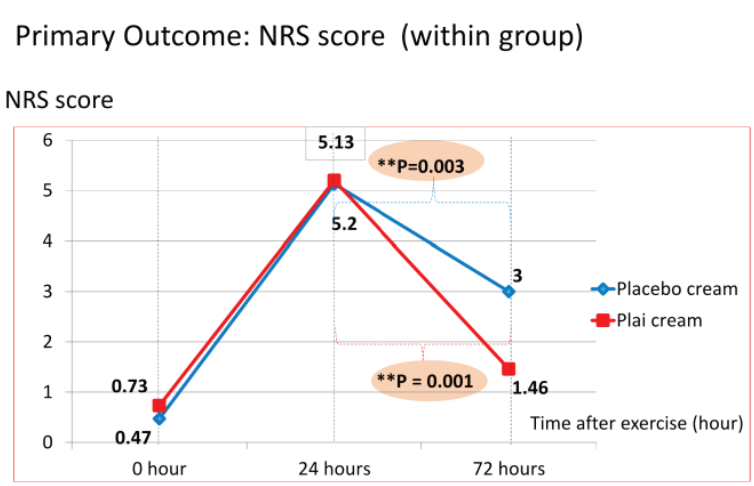

Figure 5. Change in pain rating scores in the placebo group and the *plai* cream group

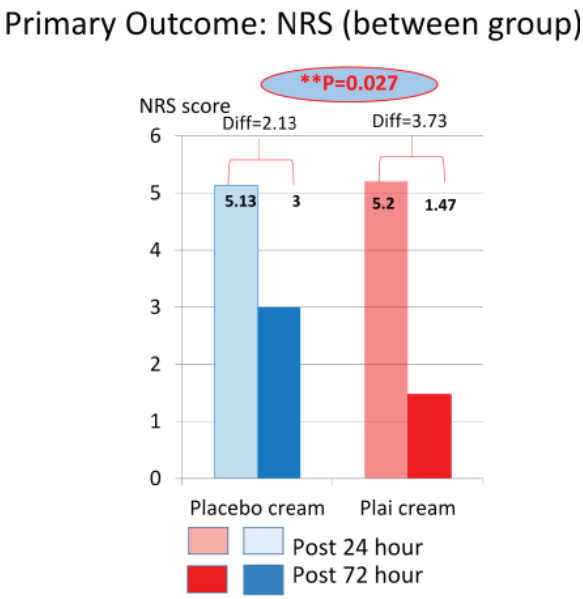

Figure 6. Comparison of pain rating scores between the placebo group and the *plai* cream group

to treat DOMS in humans.

One study showed that *plai* cream made using the traditional *plai* oil extraction method could be used to treat athletes suffering from ankle sprain (20). Local application of the cream has been demonstrated to be more effective in reducing swelling and pain compared to placebo treatment. (The group receiving placebo treatment, however, had a higher intake of paracetamol analgesic than the group treated with *plai* cream). In our study, we focused on treatment of non-dominant biceps muscles to eliminate possible confounding factors arising from the mandatory daily usage of the dominant arm and the legs.

To focus solely on treatment of DOMS condition, we excluded subjects suffering from acute muscle strain-which results in muscle pain immediately after exercise. None of the subjects in our study suffered from immediate muscle pain after the weight-training session, although all suffered from DOMS 24 hours after the session. Differences in the increase in NRS scores between the groups (4.46±0.91 for the *plai* cream group and 4.66±1.04 for the placebo group, p=0.624) were not significant.

This experiment was designed so that the active ingredients in the *plai* cream were derived solely from the *plai* oil extract and not from any other source such as methyl salicylate (which has an anti-inflammatory property (5) and is usually present in *plai* cream sold in local markets). This differs from other studies which used *plai* cream made from the recipe listed in the National Herbal Medicine Formulary which includes methyl salicylate. For these reasons, we believe that the difference in treatment results in this study was caused exclusively by the *plai* extract.

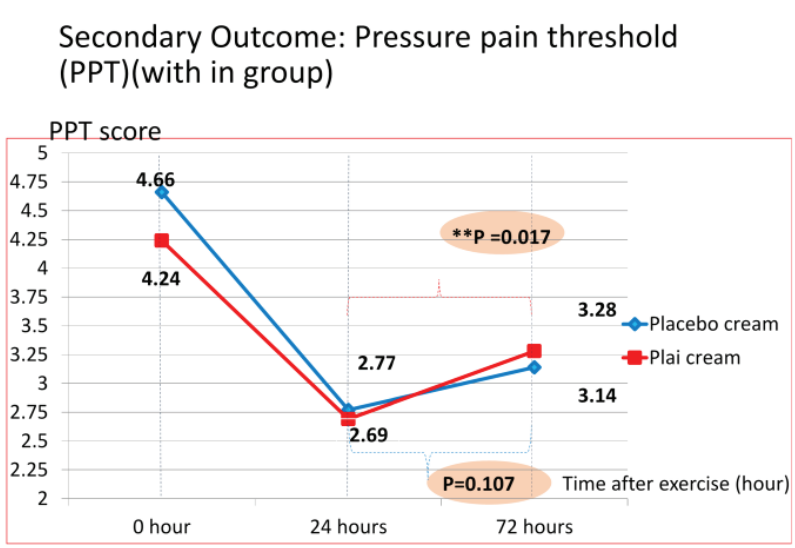

Figure 7. Pain pressure threshold change in the placebo and the *plai* cream groups

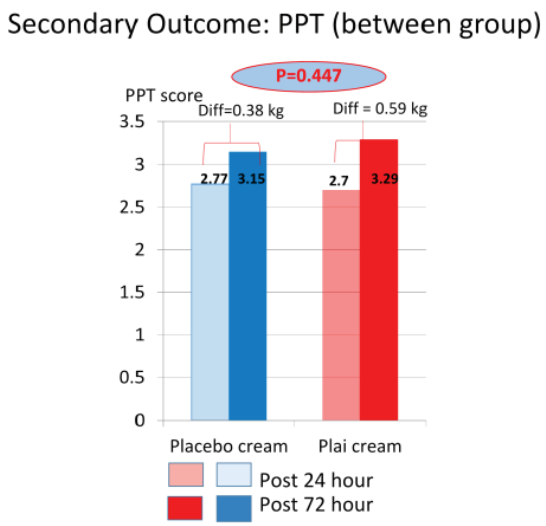

Figure 8. Pressure pain threshold comparison between the placebo and *plai* cream groups.

To account for other potential confounding factors, we added coloring and *plai* scent with no active ingredients to the placebo cream (Figures 3 and 4) to help ensure that neither the color nor the smell of the cream was a contributing factor to any differences in treatment results.

Even though both the *plai* cream group and the placebo group had decreasing NRS scores over time (15), the decrease of NRS scores in the *plai* cream group was significantly greater than in the placebo group. This showed that the natural healing process took place in both groups, but that the difference in healing efficacy resulted from the *plai* treatment.

When analyzing the volume of cream used by the two groups, we found that the *plai* group had used less total cream in their three daily applications than the placebo group: 6.56±3.66 vs 11.90±6.16 grams, respectively (p=0.008). We believe this resulted from the fact that the group which applied the *plai* cream had less pain than the placebo group.

Since we targeted the muscles in the biceps of the non-dominant arm rather than, e.g., leg muscles, the subjects were able to limit the use of the arm affected by the experiment without seriously disrupting their normal daily activities. This ensured that the subjects had little or no need to use the affected muscle during the post-experimental period, and hence the highest level of pain the subject could endure should be the same level measured during the experiment, which is 6 (from the scale of 0 to 10). The group treated with *plai* cream had a mean decrease of NRS of 3.73, while the group treated with placebo cream had a mean decrease of 2.13. The difference of 1.6 when normalized by the highest level of pain endurable is 1.6 / 6 = 26%, which is the difference in pain-reduction of the *plai* cream compared to the placebo cream.

Only the subjects in the *plai* group had a significant decrease in their PPT scores after cream treatment. However, we found no significant difference between the decrease in PPT scores between the *plai* group and placebo group. We believe this might be due to the fact that the pressure algometer was used to apply pressure only in the middle of the biceps muscle fiber, when, in fact, pain from DOMS can occur anywhere in the muscle fiber, including the origin and insertion areas. For that reason, the PPT measurements in this study might not have been effective in investigating the degree of pain experienced by the subjects. Future experiments could overcome this limitation by taking algometer measurements at different points along the biceps muscle.

Conclusions

Treatment with *plai* cream made from hot-oil *plai* extract may alleviate the DOMS pain better than placebo treatment.

Acknowledgements

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ประสิทธิภาพของครีมไพลสกัดต่อการบรรเทาอาการปวดกล้ามเนื้อหลังจากการออกกำลังกาย

จักรกริช กล้าผจญ, ณัฏฐ์ จุฑารัตนากูล และ พัฒนะ ลี
ภาควิชาเวชศาสตร์ฟื้นฟู คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

วัตถุประสงค์ เพื่อประเมินประสิทธิภาพของครีมไพลต่อการบรรเทาอาการปวดกล้ามเนื้อภายหลังจากการออกกำลังกาย (delayed onset muscle soreness; DOMS)

รูปแบบการวิจัย: การวิจัยแบบทดลองโดยปกปิดผู้เข้าร่วมโครงการและผู้ประเมินผลลัพธ์

สถานที่ทำการวิจัย: สวนดอกฟิตเนส คณะแพทยศาสตร์เชียงใหม่

วิธีการศึกษา กล้ามเนื้อ biceps ข้างที่ไม่ถนัดของอาสาสมัครชายสุขภาพดี 30 ราย ถูกกระตุ้นให้เกิด DOMS จากการยกน้ำหนักในท่า biceps curl โดยเริ่มมีอาการภายในระยะเวลา 24 ชั่วโมงกลุ่มผู้เข้าร่วมโครงงานวิจัยถูกแบ่งโดยการสุ่มออกเป็น 2 กลุ่ม คือกลุ่มที่ได้รับครีมไพลและกลุ่มที่ได้รับยาหลอก (ซึ่งแต่งกลิ่นและสีให้เหมือนกับครีมไพลแต่ไม่มีสารออกฤทธิ์) จากนั้นทำการประเมิน numeric rating scale (NRS) และ pain pressure threshold (PPT) ทั้งหมด 3 ครั้ง ได้แก่ ภายหลังจากกระตุ้นให้เกิด DOMS ทันที 24 ชั่วโมงให้หลัง และ 72 ชั่วโมงให้หลัง (โดยช่วงเวลาระหว่าง 24-72 ชั่วโมงให้หลังเป็นช่วงที่ได้รับยาไปทา)

ผลการศึกษา กลุ่มที่ได้รับครีมไพลและยาหลอกมีค่า NRS ที่ลดลงเมื่อเปรียบเทียบก่อนและหลังทายาแต่การทาครีมไพลสามารถลดอาการปวดลงมากกว่ายาหลอกอย่างมีนัยสำคัญ (3.73±1.53 vs 2.13±1.92, p=0.027) นอกจากนี้กลุ่มที่รับครีมไพลไปทายังมีระดับ PPT เพิ่มขึ้นเมื่อเปรียบเทียบก่อนและหลังทายาแต่กลับไม่พบความแตกต่างของระดับ PPT ในกลุ่มยาหลอก

สรุปผลการศึกษา ครีมไพลสามารถลดอาการปวดจาก DOMS ได้ดีกว่ายาหลอก **เชียงใหม่เวชสาร 2560; 56(2):69-79.**

คำสำคัญ: *plai* cream, delayed onset muscle soreness (DOMS), biceps, pain pressure threshold