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Development and efficacy evaluation of a personalised self-care programme for reducing work-related musculoskeletal disorders among rubber farmers in Thailand

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ABSTRACT

Introduction: Work-related musculoskeletal disorders (WMSDs), the most common causes of work-related pain, suffering, absenteeism, and disability, are a major health concern for rubber farmers. WMSDs are persistent and frequently recur, resulting in increased health burdens for workers. Fortunately, appropriate intervention may relieve discomfort. Specified interventions have been recommended to reduce incidences of WMSD.

Objective: This study aimed to develop and evaluate the efficacy of a personalised self-care programme (PSCP) for relieving pain caused by WMSDs among rubber farmers.

Methods: Demographic data and details concerning the prevalence of pain regions were collected using a questionnaire adapted from the Nordic Musculoskeletal Questionnaire (IOC 1.00). The evidence gained from modified questionnaires and special tests was used to develop the PSCP. The PSCP was verified by three experts (IOC 1.00). Based on the questionnaires, only participants with a pain score of 3 or higher were recruited for the study. The PSCP's efficacy was evaluated by comparing the results before application and after 28 days. A numerical rating scale was employed to estimate the degree of pain. The pathogeneses of WMSDs were confirmed with a special test performed by a physical therapist. Additionally, the levels of interleukin (IL)-6 and IL-10 were measured to determine the PSCP's effect on inflammatory molecules. The efficacy of the PSCP was analysed using a paired *t*-test.

Results: The results showed that farmers experienced the greatest discomfort in the lower back, followed by the shoulders, legs, and neck. Therefore, this PSCP was designed to alleviate work-related musculoskeletal pain in these body regions. A reduction in pain by two degrees was observed after 28 days of the PSCP ($\bar{x}_{\text{before}} = 5.26$, SD = 1.96, $\bar{x}_{\text{after}} = 2.40$, SD = 1.64, $p < 0.001$). Special tests confirmed that the number of pain regions were also decreased ($\bar{x}_{\text{before}} = 0.089$, SD = 0.067, $\bar{x}_{\text{after}} = 0.016$, SD = 0.030, $p < 0.001$). In addition, IL-10 levels increased ($p \leq 0.001$) following the PSCP, whereas IL-6 levels remained unaltered.

Conclusions: After 28 days of use, the PSCP was effective at reducing pain levels, decreasing pain regions, and promoting the production of anti-inflammatory molecules. This finding demonstrates that the PSCP could help alleviate work-related musculoskeletal pain among rubber farmers. The PSCP may be an appropriate intervention for alleviating pain.

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1. Introduction

Work-related musculoskeletal disorders (WMSDs) are major occupational health hazards that cause economic burden. Globally, based on occupation, individuals involved in farming were found to have the third-highest risk (87.7 %) of WMSDs [1,2]. Previous studies have examined the incidence of WMSDs among rubber farmers in southern Thailand. These farmers reported low-back (71.20 %), back (61.00 %), knee (30.00 %), shoulder (30.00 %), and neck (29.00 %) pain as WMSD symptoms [3,4]. Rubber farmers continuously face heavy workloads, particularly during the harvesting season [5]. In this regard, 87.70 % of rubber farmers were found to have WMSDs [2]. Farmers experiencing chronic pain from WMSDs bear the burden of self-treatment. The treatment expenses amount to 5000–10,000 baht per person per month [6]. Rubber farmers must confront occupational risk hazards while harvesting (Fig. 1(a–d)). They are required to bend down 15–30° along the rubber tree, cut the front tyre low, and stand and walk for a long period, with an average of approximately 700 rubber trees per 8000–16,000 square metres. In addition, rubber farmers collect 5–10 kg of latex by moving a bucket of that as well. The information above confirms that occupational exposure has an impact on WMSDs [7]. Occupational biomechanical risk factors faced by rubber farmers include repetitive movement, pushing muscles directly from the body, squatting, kneeling, extended standing, overexertion, and awkward posture, which can cause cumulative muscle injuries (Fig. 1 (a–d)) [8,9]. Additionally, a study revealed that rubber farmers with prolonged standing were more likely to have pain than those without this risk factor [3]. The abovementioned risk factors eventually lead to injuries to the bones, muscles, tendons, and joints and hamper other routine activities, resulting in continuous chronic acute pain (acute pain that keeps recurring for a long period) [10]. WMSDs are likely to recur among rubber farmers and can have negative impacts on their quality of life. Currently, the recommended treatment is medical intervention, which often requires multiple doctor visits, leading to increased costs. Therefore, it would be beneficial for farmers to have the option of autonomously adopting a self-care programme. A previous study demonstrated that providing a suitable self-care programme consisting of four weeks of exercise therapy resulted in significant improvements in pain compared to a control group that did not receive an exercise programme [11]. Implementing a self-care programme could help reduce the financial burden of self-treatment expenses while alleviating pain [12]. The findings of the above studies suggest that the musculoskeletal health of rubber farmers should be prioritised to reduce the prevalence of WMSDs.

A previous interventional study demonstrated that regular stretching exercises performed continuously for four weeks can reduce

Fig. 1. Illustrations of harvesting-related occupational postures. (a) Squatting down while tapping the rubber at the low panel. (b) Attempting to reach the trunk for the rubber tap in the top panel. (c) Bowing down to harvest natural latex. (d) Lifting, exerting force, and transporting weighty loads with a large latex bucket. The demonstrator's informed consent was obtained.

neck and shoulder pain [13]. However, no evidence was found to confirm whether such an intervention could impact the prolonged rehabilitation of the musculoskeletal system. Another study demonstrated that the training exercise group was able to reduce discomfort in the neck, shoulders, and lower back, whereas neither the ergonomic modification group nor the control group showed significant effects [14]. This study provided evidence of improvement with moderate exercise training, but it did not include a combination of hot and cold compressions with self-care exercises specifically targeting the lower back, shoulders, and neck. However, a different study found that, in addition to exercise, cold and hot compresses administered within an hour after exercise may help alleviate pain and inflammation [15]. An additional study found that heat compresses administered for 15–20 min might enhance blood flow, decrease joint stiffness caused by the presence of cartilage-degrading enzymes, reduce muscle spasms, decrease inflammation, increase sensitivity, and stimulate primary muscle fibres [16]. In addition, a cold compress reduces the temperature of both the muscle and joint, reduces blood flow, minimises metabolism, reduces muscle tension, inhibits contraction, and slows the pain-sensing nerves. Thus, anti-inflammatory stimuli are delivered to the spinal cord to reduce inflammation [12].

Interestingly, an investigation of biological markers' roles in monitoring inflammation and skeletal muscular rehabilitation was conducted in an animal study [17–19]. An increased proinflammatory cytokine was found in rat with skeletal muscular injury [17]. Increased interleukin-6 (IL-6) was observed following muscle stiffness and inflammation caused by frequent muscle stretching and short periods of rest in a model requiring rats to pull a bar at a high speed [18]. IL-10, an anti-inflammatory cytokine expression, was found to be consistently increased in high-replicating, low-acting rats [19]. It is possible to produce IL-10 to promote inflammatory healing in the musculoskeletal system.

As mentioned above, it remains unclear what pain relief from WMSDs would entail. Consequently, musculoskeletal pain relief needs to be elucidated, particularly regarding enhanced strength and flexibility. The possibility of developing a programme that provides long-term benefits through specific exercises should be examined. The expression of inflammatory and anti-inflammatory molecules following an intervention is of special interest. The imbalance of pro-inflammatory and anti-inflammatory cytokines in the body can cause mild, ongoing inflammation in the central and peripheral nervous systems [20]. When body posture is not ideal, constricted blood vessels and muscles can lead to inflammation. Additionally, the buildup of calcium ions in certain areas, called trigger points, can cause musculoskeletal injury [21]. The resulting inflammation has been found to be associated with an increase in pro-inflammatory cytokines. Interleukin-6 has been found to have statistically significant increases immediately after inflammation [22,23]. Interestingly, mild chronic inflammation can be reduced through early treatment, such as exercise, stretching, and hot and cold compresses [24,25]. Not only pro-inflammatory cytokines but also anti-inflammatory cytokines have been found to be altered during the progression of inflammation. Regeneration of the musculoskeletal system has been associated with IL-10. Thus, IL-10 could be utilised to detect and track decreases in inflammation [26].

As previously mentioned, rubber farmers often experience musculoskeletal discomfort and bear the burden of medical expenses. Hence, developing a self-care programme that farmers can easily follow on their own to relieve musculoskeletal discomfort would greatly help improve their physical well-being and alleviate the financial burden associated with medical expenses. Therefore, the purpose of this study was to develop and evaluate the efficacy of a personalised self-care programme (PSCP) for the rehabilitation of WMSDs in rubber farmers.

2. Materials and methods

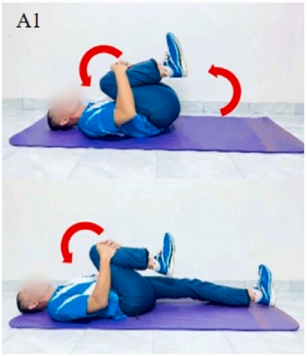
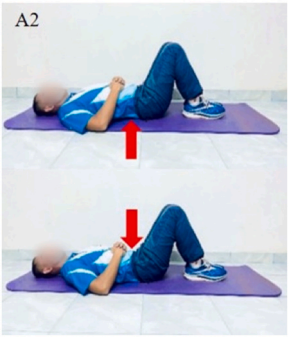
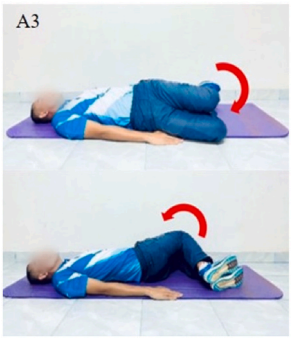
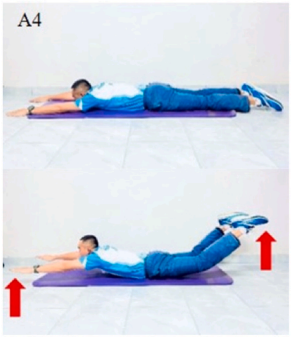
2.1. Research subjects

This pre–post intervention study was conducted between January and June 2021. This study explored the prevalence and severity of WMSDs using an adapted Nordic Musculoskeletal Questionnaire (NMQ) and a numerical rating scale (NRS). The pathogeneses of WMSDs were confirmed through special tests conducted by a physical therapist. Additionally, the levels of inflammatory and anti-inflammatory cytokines in the plasma were examined. In the first step of data collection, the sample size was estimated using the G*Power software, version 3.1.9.7 [27], and calculations were made using Cochran's formula [28]. In the second step, subjects who completed the questionnaires and met the inclusion criteria were recruited to participate in the PSCP. The inclusion criteria were as follows: 1) tapping occupation; 2) 18–60 years old; 3) two years or more of experience in rubber farming, as a working period of two years or more causes more WMSDs [29]; 4) living in Tha Khun, Taling Chan, Moklan Subdistrict, Tha Sala District, or Nakhon Si Thammarat Province; 5) pain score of 3 or above on the NRS [30]; and 6) positive confirmation of WMSDs by a physical therapist using special tests. Subjects were excluded if they had a history of continuing treatment for WMSDs at a different type of healthcare facility, including medical treatment, drug treatment, and massage therapy. Based on these criteria, 50 volunteers were selected for this study.

In the first step, the analysis among 317 rubber framers was based on a special test, pain scores, and the adapted NMQ [31–33]. Preliminary results found that the most severe pain was in the lower back, knees, shoulders, and neck. Therefore, these data were used to develop a PSCP to reduce specific pain regions for the subjects who satisfied the inclusion criteria. The developed PSCP was reviewed for suitability by three experts, including an assistant professor of physical therapy who is also a professional physical therapist and two physical therapy majors specialising in content. The designed programme had a content validity of 1.00, with which the experts agreed. The item-objective congruence consistency index [34] was between 0.67 and 1.00, ensuring ideal content validity.

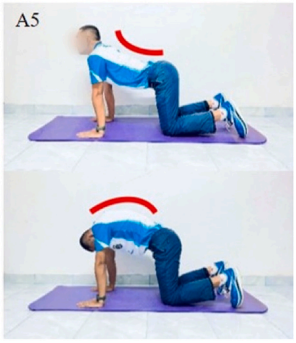
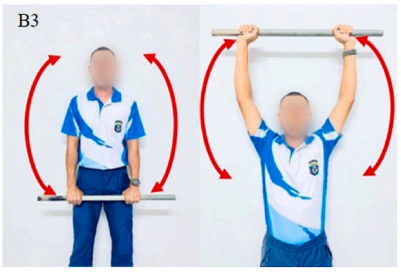
This pre–post intervention study was approved by the ethical review committee of Walailak University (WUEC-20-366-01). The images of demonstrations included in this work were obtained with the demonstrator's permission.

Table 1
The PSCP for pain rehabilitation, specifically for lower back to the hip, shoulder and arm, knees and neck.

Name of the exercise	Description
A: The self-care programme of the lower back to the hips.	
A1. Hug your knees close to your chest 	✓To stretch the lower back muscles. ✓ Lie on your back, bending your knees, one at a time. Slowly hug your knees closer to your chest. Hold your knees for a count of 1–10 (voices) and relax. Repeat 10 times on each side while stretching will feel a tightness in your lower back. If you feel pain in the knees, place your hand under the crook. ✓If the pain in the back has subsided with both knees bent up at the same time, hug your knees for a count of 1–10 (voice) and relax. Repeat 10 times.
A2. Put pressure on your back and tighten your abdomen 	✓To strengthen the back muscles by stretching the back muscles. ✓Lie on your back with both knees bent, pull in, and contract your abdominal muscles. Hold back on the floor, count 1–10 (voice) and relax slowly. Repeat 10 times.
A3. Back twisting posture 	✓ To stretch the muscles of the lower back to the legs. ✓ Lie on your back, bend both knees and slowly twist your hips to the left, hold for 1–10 (voice), then twist back and hold on the right, count 1–10. Repeat 10 times.
A4.'Superman' pose 	✓ To strengthen the core muscles, including the lower back with stretching the muscles of the back, thighs, legs, upper arms, and arms. ✓ Lie on your abdominal muscles, extend your legs and arms, and slowly lift them up and hold them for counts 1–10 (voice). Repeat 10 times.

(*continued on next page*)

Table 1 (*continued*)

Name of the exercise	Description
A: The self-care programme of the lower back to the hips.	
A5. Cat pose 	✓ To strengthen the core muscles, including the lower back This is done in conjunction with stretching the back muscles. ✓ Creep up and tug at your abdominal muscles, slowly bending your back up until you feel tightness in your back. Hold for 1–10 (voice) and repeat 10 times. Slowly bend your back until you feel tightness in your abdominal muscles. Hold for 1–10 (voice). Repeat 10 times.
B: The self-care programme of shoulder and arm.	
B1. Shoulder rotation 	✓ Stand and bend your back slightly. The side that does not have symptoms is on the table to support the weight. The opposite side should release the arm hanging straight down from the shoulder. Slowly turn the arm in a circular motion. Start with a small circle, then gradually expand to a wider circle, doing 10 times/round on each side. ✓ Do not use hanging swings and do not do it with much force.
B2. Climbing the wall 	✓ Stand facing the wall, and then slowly slide your hand from the bottom up to the top. Start at waist level to the end of your arms. Slowly until you feel tight but no pain. Hold for a count of 1–10 (voice). Slowly move your hand down. Repeat 10 times, then alternate sides.
B3. Raise a stick 	✓ Use a stick that fits the width of the shoulders on both sides. The stick should be lightweight. ✓ Holding a stick with both arms parallel to each other, arms extended, elbows straightforward. Raise the stick as high as you can until it feels tight. Hold for a count of 1–10 (voice). Repeat 10 times/round.

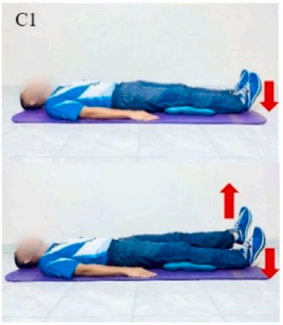
(*continued on next page*)

Table 1 (*continued*)

Name of the exercise	Description
A: The self-care programme of the lower back to the hips.	
B4. Back rubbing 	✓ Hold the towel of the right size behind you. Hands at the top pull the fabric up as much as possible. Hold for counts 1–10 (voice). Repeat 10 times/round. ✓ Alternately use the lower hand to pull the towel down as much as possible, and hold for counts 1–10 (voice). Repeat 10 times/round. ✓ Do the same as above for the opposite side.
B5. Hand reach 	✓ Stand or sit, and bring your arms around the front of your body. Grasp the opposite elbow. Gently push the back of the elbow up until you feel tightness but no pain in the shoulder that is reaching. Hold for a count of 1–10 (voice). Repeat 10 times/round on each side.
B6. Hoist 	✓ To increase the range of motion of the sore shoulder. ✓ Bring a rope or cloth and hang the overhead pulleys or beams in the front. ✓ Take both ends of the rope or cloth by hand and use your unaffected arm to pull the rope down to lift the aching arm keep lifting as high as you can. Without too much pain, hold for a count of 1–10 (voice) and slowly lower the rope. Repeat 10 times/round
C: The self-care programme of knees: To increase muscle flexibility together with increasing the strength of muscles, nerves, tendons, bones, and joints around the knee joint.	

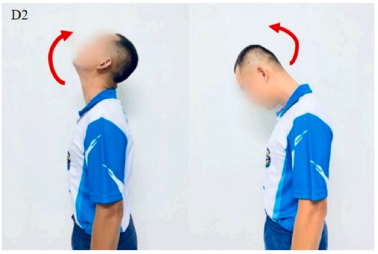
(*continued on next page*)

Table 1 (*continued*)

Name of the exercise	Description
A: The self-care programme of the lower back to the hips.	
C1. Lying on the knees 	✓ To exercise the muscles behind the knees. ✓ Lie on your back and use a small pillow under both knees. Stretch one knee as straight as possible and tense the front leg muscles above the knee. Press down until the back of the knee is attached to the pillow, hold, and count 1–10 (voice), and slowly relax. Repeat 10 times/round on each side. ✓ Then switch to heel presses, pushing the floor instead of the knees.
C2. Lie down - raise your legs - and stretch your knees 	✓ Lie on your back with one knee bent. Slowly lift the other leg, keeping the heel of one foot off the floor. Bend the toes up and hold for a count of 1–10 (voice). Slowly relax. Repeat 10 times/round on each side.
C3. Knees bent 	✓ Lie on your abdominal muscles with both legs straight. Bend one knee as much as possible. Hold contraction. Count 1–10 (voice) and stretch slowly. Repeat 10 times/round on each side.
C4. Sit - extend the knees 	✓ Sit on a chair, keep your knees straight up, tensing, count 1–10 (voice), slowly lower your leg down, and repeat 10 times/round on each side. ✓ If done well, you can add sandbags, gradually starting from 0.5 to 1 kg, respectively.
D: The self-care programme for neck: **Each stretch of the neck muscles does not have to be in sequence. Whichever position is convenient, you can do that first and can do it until all positions are more beneficial to the body.**	
D1. Stretch the lateral neck muscles 	✓ Sitting or standing upright, release your right hand by your side, then slowly tilt your head to the left until you feel tight but no pain, hold for 1–10 (voice), and repeat 10 times on each side. Increase the intensity. ✓ Use your left hand over your head to grab the right temple area, tilt the neck to the left until you feel tighter but no pain, hold on count 1–10 (voice), and slowly tilt your neck back switch on the other side. Repeat 10 times on each side.

(*continued on next page*)

Table 1 (*continued*)

Name of the exercise	Description
A: The self-care programme of the lower back to the hips.	
D2. Stretch back neck muscles 	✓ Sit or stand upright. Bow your head so that your chin touches your chest. Bend until you feel tightness but no pain. Hold for 1–10 (voice). Rest your head upright. Slowly lift your head up until you feel tightness but no pain. Hold for 1–10 (voice). Repeat 10 times. Increase the intensity. ✓ Put your hands together at the nape of your neck. Use pressure to bend down until you feel tighter. Hold for 1–10 (voice). Slowly lift your head until you feel the tension in front of your neck. Hold for 1–10 (voice). Repeat 10 times.
Stretching the neck muscles to the shoulders and back can be done for all positions	
D3. Stretches the muscles around the neck and shoulders 	✓ Sit or stand upright. Turn your face to the left as much as you can. Hold for a count of 1–10 (voice). Turn your head back straight. Repeat 10 times on each side.
D4. Stretches the muscles around the neck, shoulders, and back 	✓ Sit or stand up straight, slowly lifting both shoulders up and down 10 times.
D5. Stretches the muscles around the neck, shoulders and back 	✓ Sit or stand up straight. Turn your neck slowly to the left 10 times, then slowly turn your neck to the right 10 more times.
Cold pack	✓ You should use a cold compress before exercising. It can be done whenever there is acute pain. There are no restrictions and no danger. ✓ The acute phase has pain for the first 1–2 days: Reduce pain and inflammation with cold compress by using the finished cold sheet or a clean cloth wrapped with ice to compress the painful area or bring the part that has pain to soak into a basin of cold water for 15–20 min, 2–3 times a day, and while doing it, you will feel little cold.
Hot pack	✓ You should use a hot compress after exercising. It can be done whenever there is chronic pain. There are no restrictions and no danger. ✓ Chronic stage with pain for three days or more: Pain relief with heat, including instant hot water bags or a clean cloth moistened with warm water to compress the painful area or bring the part that has pain to soak into a basin of warm water for 15–20 min, 2–3 times a day to feel relaxed. You have better blood flow for pain relief.

(*continued on next page*)

Table 1 (*continued*)

Name of the exercise	Description
A: The self-care programme of the lower back to the hips.	
Contraindications **Precautions for safe use of the programme**	✓ Do not stretch the muscles until you feel pain. Slowly stretch until the muscles begin to tighten. Maintain position, and no rocking and stretching must be done gradually. ✓ If there is more pain that shows too much stretch, rest until symptoms are normal, then continue. ✓ You should do this regularly 1–2 times a day. It can be done both when waking up and before going to bed. When the pain is reduced, and the muscles are stronger. The frequency can be increased to 3–4 times a day, increasing the daytime and evening cycles. ✓ Should start from easier to harder movements in order by making the first movement gesture, when doing the first one well and no more pain. You begin to learn to make other movement gestures in the next sequence. ✓ Do not hold your breath during exercise. Breathe in and out normally, counting from 1 to 10 in a vocalised manner. ✓ Should be careful in person with underlying diseases such as heart disease, diabetes, or high blood pressure. It may cause chest tightness. Blackouts can be caused by bending over. ✓ If the pain is unbearably severe, you should rest for 2–3 days. ✓ Do not squeeze, massage, or bend the painful joints. It will cause more inflammation. ✓ Do not lie on the painful area. ✓ Do not use the part that is painful to lift or carry objects weighing more than 1 kg. ✓ All exercises help prevent bone deterioration due to being overused and help the surrounding muscles to be strong more difficult pain. Farmers can do whatever moves they want. ✓ Should do less per day and gradually increase until you can move normally. ✓ If you have severe pain, consult a doctor.

The demonstrator has given consent.

2.2. A PSCP among rubber farmers in Thailand

A PSCP was developed to be specific to pain relief. Data from the preliminary analysis in the first step, including demographic data, prevalence, pain regions, pain level, and data from special test results, were used to develop this programme specifically for the lower back, knees, shoulders, and neck. Stretching and strengthening exercises were applied to relieve pain and strengthen muscles. Cold and hot compresses were used to reduce acute and chronic pain, respectively. Therefore, this PSCP not only helped reduce pain but also helped strengthen the muscles. The details of the programme are shown in Table 1. Each item, shown in Figure A1 – A5, B1 – B6, C1 – C4, D1 – D5, was developed for specific regions of the body based on the analysis and data review in the first step. Previous studies have shown that stretching and strengthening exercises, in particular, can help alleviate musculoskeletal discomfort and restore normal symptoms [14,35]. Furthermore, the application of hot and cold compresses has been found to effectively reduce inflammation associated with musculoskeletal problems [15,16]. As noted above, the PSCP was evaluated and approved by physiotherapy experts, who confirmed its content validity to be 1.00. This verification indicates that the programme can be utilised, and based on our initial investigations and confirmation by the physical therapist, subjects were able to select specific pain relieve items within the PSCP. It is crucial for subjects to adhere strictly to the programme guidelines to prevent potential harm.

Subjects were trained in this PSCP right from the beginning (Day 0). The PSCP was used daily to reduce pain for specific regions in the body for 28 days. The achievements were monitored every seven days (Fig. 2). During the PSCP implementation, volunteers could perform daily activities and occupational tasks.

2.3. Assessing pain sensations of rubber farmers using the NRS

An NRS can indicate pain in numeric form through self-reporting using a straight line of 10 cm. The NRS was estimated based on the volunteers' feelings. This 10 cm scale was divided into 10 equal halves, with a difference of '1 cm in this scale,' which was equivalent to a difference of 'one level of pain'. The starting point of '0' represented *no pain*, while the ending point of '10' indicated the *worst possible pain*. The volunteers were asked to rate their pain using a number on the scale to represent their pain. According to the clinical

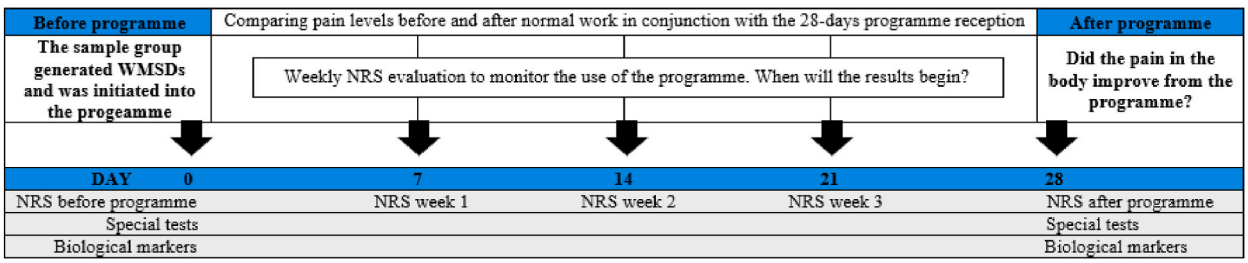


Fig. 2. Implementation of the PSCP among rubber farmers.

evaluation, the subjects' NRS scores decreased by 2 points, implying a positive change in pain. The scores were interpreted as follows: 0–1, *acceptable*; 2–3, *annoyed*; 4, *slightly tolerable*; 5, *moderate pain*; 6–7, *severe pain*; 8–9, *cannot do anything*; and 10, *severe pain* [36]. The NRS was assessed on days 0, 7, 14, 21, and 29 of PSCP implementation.

2.4. Confirmation of pain position: subjects given programme appropriate for their pain

To select the appropriate self-care programme for the specific pain region, the pain regions were determined through a self-report survey and confirmed by physical therapists. According to the WMSD screening, trigger point (TrP) palpation was performed on the subjects' muscles and fascia tissue in various areas of the body. The clinical criteria for the diagnosis of TrPs in myofascial pain syndrome (MPS) include major and minor criteria. The major criteria are as follows: 1) pain spreading over the area, 2) pain or change in sensation in the area where the myofascial TrP pattern should be painful, 3) the taut band found in not-so-deep muscles, 4) taut band having the most obvious pain points in terms of length, and 5) reduced range observed when measuring. The minor criteria are as follows: 1) pain or altered sensation aroused by pressing this pain point, 2) local twitch response stimulated by inserting the needle perpendicular to the taut band at the pain point, and 3) muscle stretching or pain injection can reduce pain. For the diagnosis of MPS, all major criteria and at least one minor criterion must be present [37].

Next, special tests were performed by a physical therapist to confirm the pathology of musculoskeletal disorders. These tests were used to confirm the hypotheses from all other physical examinations. Special tests were conducted on days 0 and 29 of the programme implementation. Physical therapy tests, including TrP palpation and special tests, were performed by professional physical therapists.

2.5. IL-6 and IL-10 investigation

This study also examined the respective levels of inflammatory cytokine IL-6 and anti-inflammatory cytokine IL-10 in blood plasma, as biological markers can be used to identify disease progression from the onset of inflammation to the anti-inflammatory stage with the use of the PSCP. Blood samples of 4 ml were collected by a professional medical technician. IL-6 and IL-10 levels were determined using BioLegend's ELISA MAX™ Standard Set (Cat# 430501 or Cat# 430601; BioLegend Way, San Diego) according to the manufacturer's protocol [38–41]. The plasma levels of IL-6 and IL-10 were examined on days 0 and 29 of the programme implementation to verify the effectiveness of the PSCP.

2.6. Data analysis

Information was obtained before, during, and after the PSCP's implementation. Descriptive statistics were used. The PSCP's

Table 2
Sociodemographic/individual characteristics of rubber farmers in the study (n = 50).

Characteristics	Category	n (%)
Gender	Male	25 (50.0)
	Female	25 (50.0)
Age (years)	18–40	8 (16.0)
	41–60	42 (84.0)
Min = 30, Max = 60, $\bar{x}$ = 47.66, SD = 8.183		
Educational status	Primary school	23 (46.0)
	Post-primary school	27 (54.0)
Marital status	Unmarried	8 (16.0)
	Married	42 (84.0)
Body mass index (BMI)	Underweight	33 (66.0)
	Healthy	3 (6.0)
	Overweight and obese	14 (28.0)
Min = 17.58, Max = 31.22, $\bar{x}$ = 23.181, SD = 3.073		
Smoking	No	35 (70.0)
	Yes	15 (30.0)
Working experience (years)	2–15	33 (66.0)
	>15	17 (34.0)
Min = 2, Max = 40, $\bar{x}$ = 15.20, S.D. = 9.967		
Work position	Farm owner	38 (76.0)
	Employee	12 (24.0)
Physical activity	No	18 (36.0)
	Exercise three days per week	13 (26.0)
	Stretching three days per week	4 (8.0)
	Household activity	15 (30.0)
Income sufficiency[a]	Not enough (5000–15,000 baht)	19 (38.0)
	Enough but not enough left over (>15,001–20,000 baht)	24 (48.0)
	Enough to keep (>20,001 baht)	7 (14.0)
Stress/Anxiety	No	26 (52.0)
	Yes	24 (48.0)

[a] Based on household consumption expenditures of southern Thai people at an average of 17,095 baht.

efficacy was analysed by comparing pain scores, results from special tests, inflammatory cytokine, and IL-6 and IL-10 levels using the paired *t*-test. Normalisation was performed using the Kolmogorov–Smirnov test for $n \geq 50$ prior to the paired *t*-test. If $p > 0.05$, the null hypothesis was accepted, and the data were referred to as normally distributed.

3. Results

3.1. General sociodemographic/individual characteristics

Table 2 presents the sociodemographic/individual characteristics of the study subjects. This clearly shows that the rubber farmers in this study were equally of both genders, and their average age was 48 years. The income of most of the rubber farmers was found to be a sufficient amount based on the average household consumption expenditures in southern Thailand, which is 17,095 baht. Of the sample, 48 % reported experiencing stress or anxiety. A majority of the rubber farmers were farm owners (76 %). The average working experience was 15 years, with 54 % having graduated from high school (54 %). Other factors included non-smoking (70 %) and non-exercise (36 %).

3.2. Work-related risk factors for WMSDs

Table 3 presents the work-related risk factors for WMSDs among the study subjects. The ergonomic risk factors revealed that the most common causes of WMSDs were repetitive movement and muscle tension directly in the body. In addition, ergonomic risk factors affecting at least 50 % of the subjects included squatting (56 %), kneeling (56 %), and heavy workload (50 %). Most of the rubber farmers worked 5–12 h per day, with a holiday of only 0–2 days per week. In addition, most had break time during the day. Rubber farming is an inheritance career, and the farmers often work without training (habitual work), although most in this study had agricultural registration.

3.3. Prevalence of WMSDs

In this investigation, in addition to the subjective NMQ, a special test was conducted. The results, shown in Fig. 3, revealed that the most severe pain was reported in the lower back, knees, shoulders, and neck. This study explored the prevalence and severity of WMSDs using an adapted NMQ. Furthermore, the pathogeneses of WMSDs were confirmed through special tests conducted by a physical therapist. Most subjects experienced pain symptoms in several regions of their bodies, as confirmed by the special test conducted by a physiotherapist. The location of the TrP and taut band, where the farmers often had a jump sign, had decreased degrees

Table 3
Work-related risk factors for WMSDs among study subjects (n = 50).

Characteristics	Category	n (%)
Working task (More than one answer)	Rubber tapping	40 (80.0)
	Rubber collecting	37 (74.0)
	Rubber tree care	34 (68.0)
Working days off per week	0–2 days per week	38 (76.0)
	≥3 days per week	12 (24.0)
Working hours per day	1–4 h a day	14 (28.0)
	5–12 h a day	36 (72.0)
Break time in a day	No	9 (18.0)
	Yes	41 (82.0)
Inheritance career	No	13 (26.0)
	Yes	37 (74.0)
Overtime	No	31 (62.0)
	Yes	19 (38.0)
Agricultural registration[b]	No	6 (12.0)
	Yes	44 (88.0)
Work without training (habitual work)	No	9 (18.0)
	Yes	41 (82.0)
Ergonomics risk factor	Repetitive movement	43 (86.0)
	Muscle tension directly in the body	36 (72.0)
	Squatting	28 (56.0)
	Kneeling	28 (56.0)
	Heavy workload (harvesting for ≥7 h)	25 (50.0)
	Heavy lifting[c]	23 (46.0)
	Prolonged standing	14 (28.0)
	Exertion more than usual	10 (20.0)
	Awkward posture[d]	8 (16.0)

[b] Rubber farmers (subjects) registered with the Ministry of Agriculture and Cooperatives.
[c] Lifting and moving latex buckets weighing ≥ 10–60 kg continuously for 2–3 h.
[d] Positions of the body that deviate greatly from the neutral position during work activities.

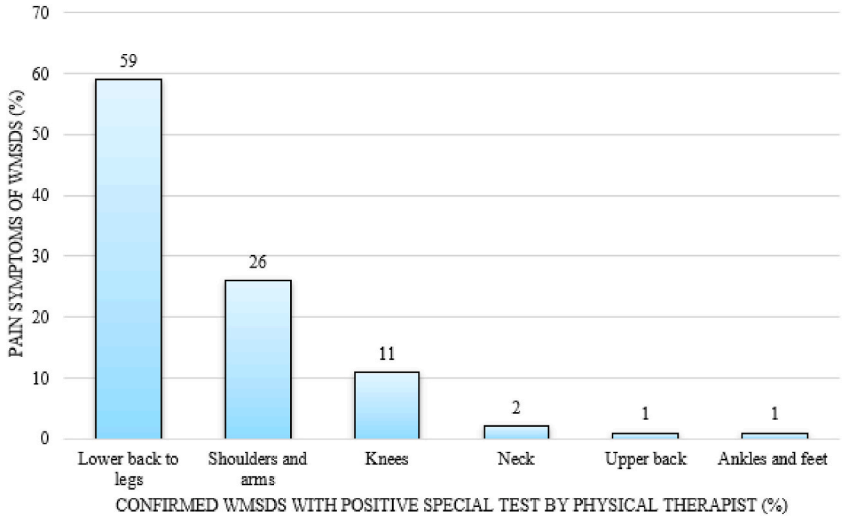


Fig. 3. The prevalence of WMSDs among study subjects (n = 50).

of movement. The lower back to the leg was the most commonly reported region with pain, followed by the shoulders and arms, knees, and neck.

3.4. Comparison of the results of special tests

The results of the special tests among rubber farmers are presented in Table 4. The pathogeneses of WMSDs were confirmed using special tests conducted by a physical therapist before and after the programme. Normalisation analysis was significant at $p > 0.05$. The pain regions were found to be significantly reduced ($p = 0.00$) after PSCP implementation. After 28 days of the programme, subjects had fewer musculoskeletal abnormalities than before the programme ($\overline{x}_{\text{before}} = 0.089$, SD = 0.067, $\overline{x}_{\text{after}} = 0.016$, SD = 0.030, $p = 0.00$), as confirmed by special tests.

There was a statistically significant difference at the 0.05 level ($p = 0.00$); paired *t*-test. More than one symptom per rubber farmer was found.

Table 4
Comparison of the results of special tests before and after PSCP implementation.

Special tests	Subjects who had pain % (n)	
	Before programme	After programme
Area of the lower back to the leg		
Prone knee bend test (PKB) (L1–L3 level nerve roots)	42.00 % (21)	2.00 % (1)
Thomas test (iliopsoas contracture, hip flexors)	30.00 % (15)	6.00 % (3)
Straight leg raising test (SLRT) (sciatic nerve and nerve roots L4, L5, S1 levels)	26.00 % (13)	8.00 % (4)
Hamstring contracture test (posterior thigh muscles, leg)	20.00 % (10)	6.00 % (3)
Rectus femoris test (front thigh muscles, leg)	12.00 % (6)	8.00 % (4)
Crossover test (nerves, intervertebral discs)	12.00 % (6)	4.00 % (2)
Area of the shoulder and arm		
Yergason's test (shoulder ligament)	22.00 % (11)	2.00 % (1)
Lateral epicondylitis or tennis elbow (outer elbow bone and lower arm)	12.00 % (6)	2.00 % (1)
Drop arm test (shoulder ligament)	8.00 % (4)	–
Impingement test (shoulder ligament and bone)	6.00 % (3)	–
Phalen's test (nerve)	6.00 % (3)	–
Medial epicondylitis or golf elbow (inner elbow bone and lower arm)	4.00 % (2)	–
Area of the knee		
Zohler's sign (patella)	10.00 % (5)	2.00 % (1)
McMurray test (knee joint pillow)	8.00 % (4)	–
Valgus stress test (knock knees; inner knee ligament)	4.00 % (2)	4.00 % (2)
Varus stress test (bow legs and outer knee ligament)	4.00 % (2)	–
Area of the neck		
Cervical compression test (nerve root)	4.00 % (2)	–

3.5. Comparison of pain scores

Fig. 4 presents the average NRS scores. The feelings of the volunteers were investigated using the NRS under the supervision of a physical therapist. It is important to note that the pain scores were confirmed by the physiotherapist. Normalisation analysis was significant at $p > 0.05$. A statistically significant difference at the 0.05 level ($p < 0.01$) was found. After PSCP implementations, the study subjects had lower pain scores than before the programme ($\overline{x}_{\text{before}} = 5.260$, SD = 1.957, $\overline{x}_{\text{after}} = 2.400$, SD = 1.641, p = 0.00). In addition, a reduction in pain scores was observed every week (Week 1: Min = 2.00, Max = 8.00, $\overline{x} = 5.24$, SD = 0.706; Week 2: Min = 1.00, Max = 8.00, $\overline{x} = 4.66$, SD = 1.69; Week 3: Min = 1.00, Max = 8.00, $\overline{x} = 3.64$, SD = 1.61).

After PSCP implementation, the study subjects had lower pain scores than before the programme (before the programme, Min = 3, Max = 10, $\overline{x} = 5.26$, SD = 1.96; after the programme, Min = 0, Max = 7, $\overline{x} = 2.40$, SD = 1.64, $p < 0.00$).

3.6. IL-6 and IL-10 levels

The levels of inflammatory and anti-inflammatory cytokines in the plasma were evaluated, as biological markers can be used to determine the progression of inflammation and the PSCP's effects. The IL-6 level after the programme's implementation (Week 4) was not significantly different than that before the programme's implementation. Normalisation analysis was significant at $p > 0.05$.

However, IL-10 levels were significantly increased after the programme's implementation compared to before the programme's implementation ($p < 0.001$; Fig. 5).

4. Discussion

This study demonstrates the efficacy of the developed PSCP. Farmers with early-stage WMSDs can choose a suitable pain relief solution through physical exercises, stretching exercises, and cold and hot compresses. The PSCP was effective in reducing pain by up to 3 points on the NRS, thus meeting the benchmark confirming that this PSCP is practical [36]. This study is a preliminary report discussing Thai rubber farmers' experience of a PSCP specifically designed for different pain regions, including the lower back, shoulder, knee, and neck. Farmers can use a PSCP to reduce pain in several regions at the same time. This finding revealed that reduced pain scores were observed after the first week of the programme, and the scores continued to decrease every week.

This study demonstrated the efficacy of PSCP in reducing pain scores and regions and promoting increases in anti-inflammatory activity after 28 days of use. In the development of the PSCP, each item had the purpose of addressing specific pain regions. All tasks had a suitable amount of repetition and would not trigger damage to the muscles. The PSCP consisted of stretching and strengthening exercises. The proper duration for applying hot and cold compresses was suggested. Previous research suggests that applying hot or cold compresses after exercise can reduce inflammation-related discomfort [15]. Early muscle pain treatment with exercise, stretching, and hot and cold compresses has been shown to effectively reduce inflammation [24,25]. Previous research has shown that performing strengthening and stretching exercises is more effective in reducing neck muscle pain than receiving massage alone or exercise followed by massage, particularly in patients with subacute or persistent disabling neck pain. It has also been observed that subacute (30–90 days) or chronic (90 days) pain may require an increase in exercise duration; however, prolonged exercise may lead to pain [35]. It has been found that, after six weeks of exercise, non-specific chronic neck pain can be relieved [42]. In addition, scapular muscle strength improvements have been found to be more beneficial for chronic neck pain patients than cervical stabilisation exercises, with noticeable results within four weeks (28 days) [43]. Engaging in a four-week stretching exercise

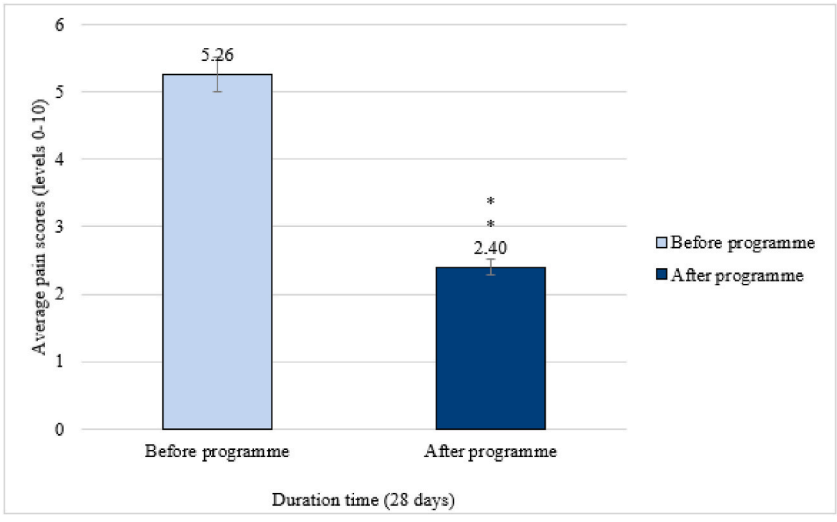


Fig. 4. Graph of average pain scores using the NRS. Paired *t*-test, **significant at $p < 0.01$.

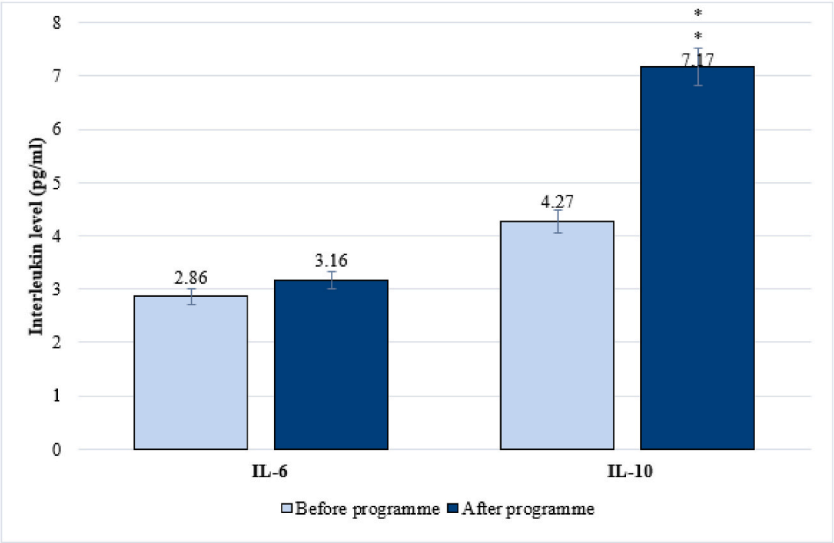


Fig. 5. Comparison of IL-6 and IL-10 levels before and after receiving the programme. Paired *t*-test, **significant at $p < 0.01$.

programme has been shown to effectively reduce neck and shoulder pain [13]. The PSCP could possibly be effective in reducing pain and pain areas after 28 days of use, as the participants in this study did not have chronic pain. However, despite the finding that the PSCP can reduce the pain score, some subjects still experienced discomfort. Therefore, taking a break before resuming the use of the PSCP was recommended. Further research should be conducted on the optimal recuperation period. The PSCP was developed with the primary objective of targeting and addressing pain regions in individuals.

This finding showed that the positive result of WMSDs had the most confirmation through the straight leg raising test, with decreases found after the programme. Findings showed that many of the rubber farmers had lesions at the sciatic nerve and nerve roots of the fourth lumbar vertebrae, fifth lumbar vertebrae, and first sacrum levels, which can take a long time to heal. The level of strain was reduced after the PSCP. Interestingly, the PSCP can relieve pain at the nerve root level. For that reason, the PSCP included strengthening exercises coupled with stretching exercises, which helped restore joints, tendons, and ligaments, relieve bone and muscle injuries and pain, treat the spine, and properly control nerve root compression and muscles [44]. One part of the muscle must contract, and the other must relax to function appropriately [35]. If any musculoskeletal system is painful, its function is also abnormal and develops into a disorder. The most common pathology of WMSDs among the study subjects was MPS, which was detected by palpation with a special examination [45]. Moreover, hot and cold compresses were recommended to reduce inflammation.

One noteworthy finding of this study is that a personal intervention programme can help subjects identify individual pain areas. If inflammation occurs because of MPS, the pain can be reduced with hot and cold compresses. The effect of heat compression is that the elevated tissue temperature causes blood vessels to expand, leading to increased blood flow. This makes the hot compress suitable for chronic acute pain. In this study, the participants continued to suffer musculoskeletal injuries, and the exacerbation indicated chronic acute pain [46]. Notably, heat improves the flexibility of muscles and joints, providing a feeling of relaxation [47]. In the region subjected to cold compression, the lower temperature makes the tissue less flexible and narrows blood vessels. Cold compressions thus help reduce swelling [48]. This is an additional mechanism by which the PSCP enhances pain relief.

This study demonstrated a greater pain reduction effect than other studies reporting pain reduction following eight weeks of physical activity [11]. A physical exercise programme may reduce musculoskeletal pain more slowly than physical exercises combined with stretching and cold or hot compresses. Variations may also be found depending on the population, the individual, and work-related factors. In a previous study, the effective size for a physical intervention study was reported as 23 participants. After 12 weeks of training with low-repetition or high-repetition resistance, a reduction in the inflammatory marker was observed [49].

This study documented the usage of PSCP in 50 rubber farmers with chronic acute pain. The study also estimated the levels of inflammatory and anti-inflammatory cytokines in blood plasma. A reduction in inflammation was observed. IL-10 (anti-inflammatory cytokines) levels were increased after the programme. This is consistent with a previous report finding that, in 12 weeks, IL-10 can inhibit inflammatory cytokine IL-6 [50]. This finding displays the same trend as in previous studies. Exercise for 4–12 weeks can produce the desired IL-10 levels [51–53]. This result is consistent with other research demonstrating the effectiveness of IL-10, which is produced during exercise [54]. Additionally, IL-10 inhibits TNF-α, which affects IL-6 function in adults [55]. Previous studies have shown that IL-10 plays a role in the regeneration of bones and muscles with proper care [56,57]. In this study, musculoskeletal pain was found to possibly affect IL-6 levels, but this effect was only slight and not statistically significant. This may be caused by the rubber farmers still working normally, which requires continuing strenuous work [58]. This PSCP can likely restore musculoskeletal injuries at the molecular level through anti-inflammatory mechanisms. However, further studies on other inflammatory mechanisms are needed. Although this study demonstrates that IL-10 can be used to detect WMSD progression and monitor inflammation reduction, IL-10 and IL-6 levels should also be evaluated further.

This study has a few limitations that should be addressed. This study collected ergonomic risk data through a questionnaire in which subjects recalled their previous work processes. Future investigations are recommended to employ alternative ergonomic assessment tools, such as wearable sensors, to enhance precision and reliability. In addition, it is recommended that alternative ergonomic assessment tools, such as wearable insole pressure systems [59], inertial measurement units (IMU) [60], or vision-based posture [61], be employed to enhance precision and reliability. This study focused on reducing muscle pain caused by working posture. Additional research is required to improve working posture or ergonomic factors. Further studies on IL-6 should be conducted to analyse their relevance. Other physical activities and mental stress levels remain factors that should be researched further, and further research is required to understand the relevance and prediction of various PSCP characteristics. For farmers, continuing to work as usual can result in inflammation. The inability to measure the intensity of everyday activities in the study subjects' occupation must be overcome.

5. Study implications and practical contributions

The developed PSCP can be used to reduce pain caused by musculoskeletal discomfort in farmers and other workers. In addition to pain relief, the PSCP can also contribute to muscle strengthening. Farmers can select suitable items to alleviate pain in specific regions of discomfort. The safety precautions were outlined in the PSCP, as shown in Table 1. Distributing the PSCP to public health organisations and personnel, especially rural hospitals, is recommended. In Thailand, village health volunteers play a crucial role in delivering healthcare services to people residing in rural areas. Involving village health volunteers in the PSCP implementation would offer an additional avenue for promoting the well-being of the agricultural community.

6. Conclusions

This study aimed to develop and evaluate the efficacy of a PSCP for relieving pain caused by WMSDs among rubber farmers. The data were collected using the NMQ numeric rating scale, and special tests were employed to develop the PSCP. The highest levels of discomfort were noted in the lower back, shoulders, knees, and neck, respectively. The PSCP was designed specifically to address pain in different regions and was easy to apply, enabling farmers to self-administer it for pain relief. The PSCP was composed of physical exercises, stretching exercises, and cold or hot compresses tailored to the pain experienced by different rubber farmers. The effectiveness of the PSCP for those with pain of Grade 3 or higher was evaluated after 28 days of testing. Subjects could relieve WMSD-associated pain by following contraindications and precautions for the safe use of the programme. The PSCP can be effective in reducing pain, especially in individuals experiencing early pain. After 28 days of the programme, farmers with WMSDs experienced reduced pain sensations by two degrees ($\bar{x}_{\text{before}} = 5.26$, SD = 1.96, $\bar{x}_{\text{after}} = 2.40$, SD = 1.64, $p < 0.001$). Special tests confirmed that the pain regions were also decreased ($\bar{x}_{\text{before}} = 0.089$, SD = 0.067, $\bar{x}_{\text{after}} = 0.016$, SD = 0.030, $p < 0.001$). The discomfort in those regions was also alleviated. Moreover, the PSCP was found to aid in the recovery of musculoskeletal injuries by promoting the expression of the anti-inflammatory cytokine IL-10. The IL-10 levels increased ($p \leq 0.001$) following the PSCP in the blood plasma.

This study demonstrated that a PSCP could help reduce work-related muscular pain as soon as one month. In light of the evidence presented above, it can be confirmed that the PSCP is effective in reducing pain associated with musculoskeletal disorders. The PSCP should be promoted for application in subdistrict health promotion institutions and other medical facilities. Additionally, distributing it to village health volunteers would help promote public health in rural regions. Implementing the programme at an early stage of pain can also dramatically cut the expenses and amount of time the workers spend at the hospital. Departments of occupational health and safety can maximise this programme's benefits for workers. For further study, this PSCP could be further expanded to reduce WMSDs in other regions of the body.

Ethics declarations

This study was reviewed and approved by the ethical review committee of Walailak University, with the approval number: WUEC-20-366-01. All participants provided informed consent to participate in the study. All participants/demonstrators provided informed consent for the publication of their anonymised case details and images.

Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Parnchon Chokprasit: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Visualization. **Supabhorn Yimthiang:** Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Siriluk Veerasakul:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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