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The short effect of sports liniment on muscular physiological responses and physical performance among male Muay Thai fighters: Case study

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ABSTRACT

Background: Sports liniments are commonly used as a preparatory phase before an activity. Muay Thai fighters, such as Namman Muay (NM), have generally been used, but the scientific evidence on physiological and sports performance effects has not been studied.

Objective: This case study aimed to investigate the effects of NM sport 'boxing' liniment on muscular physiological responses and physical performance outcomes among male Muay Thai fighters.

Materials and methods: Four Muay Thai fighters were recruited into the case study and equally divided into two groups: the tape stripping (TS) (N=2) and the massage (MG) groups (N=2). The TS group received 20 tape strips across the muscle before receiving 3 mL of NM, while the MG group received 3 mL of NM with an effleurage massage for 5 minutes. Two tests were performed on Day 1) with no application of NM, and on Day 2), 3 mL NM was applied and randomly allocated into the TS group or MG group. Physiological responses such as skin temperature (ST), muscle oxygen (SmO_2), myoglobin (Mb), and hemoglobin (Hb) were evaluated by Fluke thermography and Moxy Monitor (Near Infrared Spectroscopy; NIRS). Physical performance as knee extensor and hip flexor strength was assessed using a Lafayette handheld dynamometer and isometric endurance hip flexion test as a time to failure (TTF). Data analysis was performed using a descriptive study, evaluating the data results between two days of the experiment.

Results: ST did not increase after application of NM or receiving either TS or MG. SmO_2 Mb percentage for the TS group increased between day 1 and day 2, with a mean difference of 10.78. The MG group observed only one participant increasing Mb with a group mean difference of 7.56. The Hb percentage observed little change and remained relatively constant between the two days. There were no observational differences in knee extension strength; however, Hip flexion strength observed more significant increases in the TS group, with a mean of 2.45 kg, while the MG group observed a mean increase of 0.65 kg after receiving the NM. The isometric endurance test observed increases in both groups, with higher increases in the MG group mean of 66.43 sec and TS group mean of 37.33 sec, after having NM applied. The 3 mL NM applied onto the Rectus Femoris muscle as a precursor to a warm-up increased SmO_2 values.

Conclusion: Tape stripping with NM enhances its permeation and may improve isometric strength, while massage with NM appears to increase isometric muscular endurance among male Muay Thai fighters.

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Introduction

The study delves into the widespread presence of Muay Thai gyms in Thailand and globally, underlining the popularity of sports liniment such as Namman Muay (NM) among athletes, with 30% of sales attributed to its use. Namman Muay, a product containing 31% Methyl Salicylate and 1.25% menthol, known as active pharmaceutical ingredients (APIs), has a rich historical and cultural significance within Muay Thai.[1] With an estimated three hundred million Muay Thai practitioners worldwide,[2] the product's association with the sport has been instrumental in its success. Also, Muay Thai training camps in Thailand provide both fighting and cultural insights.[3]

Despite the everyday use of warm-up rubs like NM by Muay Thai athletes to enhance performance and aid in injury recovery, there is a noticeable lack of academic studies focusing on the specific use of sports rubs in Muay Thai. However, general warm-up and recovery principles suggest that such rubs can benefit fighters by improving their performance and aiding recovery. Over-the-counter sports rubs in Thailand contain two key APIs: methyl salicylate and L-menthol. These APIs serve as counterirritants on the skin, inducing sensations of warmth and soothing effects,[4] dilating surface blood vessels, ultimately desensitizing sensory neurons, and alleviating pain.[5]

The challenge lies in determining how effectively sports liniments penetrate the skin to warm underlying tissues, potentially increasing muscle oxygenation or acting as an analgesic. Quantifying the penetration and absorption of APIs, particularly in the dosage form, poses difficulties for pharmaceutical researchers. The skin, the body's largest organ, presents a significant intrinsic and extrinsic barrier, with the stratum corneum acting as a formidable obstacle for APIs. Pharmaceutical companies have explored using nanoparticles, including prodrugs like methyl salicylate, to enhance permeation, especially for drugs with poor solubility or permeability.[6]

In the pursuit of enhancing permeation for topical applications, various extrinsic methods have been proposed. While some techniques require expensive equipment, cost-effective methods like massage and tape stripping have shown promise. A recent study demonstrated that local perfusion and systemic Hemodynamics using effleurage, comparing massage limbs, showed significant differences with increases in two outcome measurements, using laser Doppler flowmetry and reflection photoplethysmography.[7] Recent research has highlighted the efficacy of tape stripping in enhancing drug delivery,[8] percent for substances like caffeine (28.2%), sorbic acid (21.6%), and testosterone (7%) when employing tape stripping compared to non-tape stripping methods.[9] Thereby, tape stripping demonstrates notable enhancements in drug uptake percentages for various substances.

This study focuses on the Muay Thai kicking technique, specifically the roundhouse kick (RHK), known for heavily engaging the rectus femoris hip flexor and knee extensor muscles.[10] RHK is a favored technique among fighters due to its combat effectiveness.[11] Nevertheless, the efficacy of topically applied sports rubs for warm-up purposes remains inconclusive. By pinpointing the rectus femoris muscle, it becomes possible to isolate and concentrate on strength testing, underscoring the significance of overall muscle strength in optimizing athletic performance. In general, valuable muscular strength values can be obtained by identifying specific muscle groups for strength evaluation, such as through isometric strength testing using handheld dynamometers. This is essential as muscular strength is vital in improving athletic performance by enhancing force-time characteristics, which are crucial for an athlete's ability to execute various sports-specific skills effectively. The pursuit of muscular strength values in sports is driven by the desire to optimize performance and prevent injuries, tailor training programs, facilitate long-term athlete development, and contribute to the body of scientific knowledge in sports medicine science.[12] The rectus femoris muscle, serving as both a hip flexor and knee extensor, can lead to unusual strength values during assessments due to its biarticular nature crossing the hip and knee joints. This complexity arises from its ability to simultaneously influence movements at both joints, affecting strength measurements depending on the hip and knee positions during testing. Studies indicate that muscle length during exercises impacts muscle damage and strength output, with variations in strength values observed based on different activities such as sprinting or walking.[13,14] Factors such as joint angles and assessment methods like isometric and isokinetic testing contribute to the uniqueness of strength measurements in the rectus femoris muscle. This study measures isometric strength and endurance. The handheld dynamometer measures the maximum force output (strength), while the muscular hold for time to failure measures the duration of sustained contraction (endurance). While both tests are valuable, they serve different purposes in assessing muscle function. Strength assessments can help diagnose conditions related to muscle weakness, whereas endurance tests can inform training programs and rehabilitation strategies focused on improving stamina.[15]

Raising skin temperature is crucial for preparing for combat sports such as Muay Thai. This process enhances muscle flexibility and performance, reducing the risk of strains and injuries during intense activities. Backed by research, effective warm-up routines can reduce injury rates by up to 50% in various sports.[16,17] A proper warm-up readies the neuromuscular system, improving coordination and reaction times for executing combat sports techniques. It also primes the cardiovascular system for the physical demands of Muay Thai, ensuring endurance during training sessions. Dynamic stretching and sport-specific drills boost muscle blood flow, elevating skin temperature and enhancing flexibility. Starting a warm-up at a lower intensity and gradually increasing it helps minimize the risk of cardiac stress and muscle damage. Elevated skin temperature is vital for peak performance and injury prevention in Muay Thai. A structured warm-up routine incorporating dynamic movements and intensity progression effectively prepares

athletes for the rigors of their training.[18]

Perrey's emphasis on the complexity of muscle oxygenation in human physiology during exercise underscores the importance of understanding this process.[19] Near Infrared Spectroscopy (NIRS) has emerged as a valuable tool for measuring physiological oxygen indicators in sports and exercise.[20] The Moxy monitor, enabling real-time and continuous monitoring of muscle oxygen levels, is vital in enhancing aerobic capacity without compromising speed, essential attributes for Muay Thai practitioners. Studies have shown that muscle isometric voluntary contractions may be linked to increased SmO_2 levels, underscoring the importance of monitoring athletes to aid their development and objective achievement.[21]

Thus, the primary objectives of this case study were to evaluate the effects on muscle oxygenation, myoglobin (Mb) and hemoglobin (Hb) oxygen levels, knee extension/hip flexion strength, and isometric muscle endurance following the application of 3 mL of NM to the muscle, administered through either tape stripping or massage techniques, among male Muay Thai fighters.

Materials and methods

Participants

The research protocols underwent thorough evaluation and approval by the Centre for Ethics in Human Research at Khon Kaen University, Thailand (Ref No: HE662203). The study involved Muay Thai trainers from a gym in Khon Kaen, Thailand, who met specific criteria: actively training fighters daily and having engaged in fights within the past 18 months. They agreed to refrain from consuming alcohol and energy drinks before the study. Exclusion criteria encompassed allergies to aspirin, heart conditions, recent injuries, and sensitivity to tape. Each participant's dominant leg, used for kicking, was determined. The research was conducted in a controlled setting between 9:00 am and 3:00 pm, maintaining a temperature of around 21 °C.

Experimental procedures

The experimental design comprised two days of testing. On Day 1, participants underwent assessments without using sports liniment or any interventions. Measurements included oxygen values, skin temperature, isometric strength tests for knee extension and hip flexion, and assessing isometric hold time to failure (TTF).

On Day 2, participants were randomly assigned to either the TS group (black card) or the MG group (red card) through a selection process using playing cards. Both groups received the application of 3 mL of sports liniment. Before the experiment, participants underwent health screenings and physical anthropometrics. They then engaged in the same experimental measurement protocol as seen on Day 1. i.e., oxygen and skin temperature were recorded, and various strength tests were performed using a handheld dynamometer and a kettlebell.[22]

Interventions

The tape stripping (TS) group had 20 tape strips applied to the rectus femoris muscle of their dominant kicking leg within a 9x6 cm patch (Figure 1), followed by using 3 mL of sports liniment inside the patch. Conversely, the massage group (MG) had the same 9x6 cm patch applied over the rectus femoris muscle of their dominant kicking leg, with the sports liniment applied within the patch, followed by a 5-min session of massage/effleurage.

Figure 1*. The 9x6 cm patch used to contain the Namman Muay.*

Outcome measurements

Skin temperature

Skin temperature was measured using a Fluke Thermography camera (TiS20+ Max thermal imaging camera, Fluke®, Washington, USA), known for its reliability and accuracy within the specified temperature range. The camera was positioned at a standardized distance and angle from the rectus femoris muscle, ensuring consistent and precise recordings. Infrared thermographic cameras showed excellent reliability in both intra and inter-measurements.[23-25]

Muscle oxygenation

Muscle oxygenation was assessed using the Moxy Monitor (Moxy 5, Fortiori Design, Minnesota, USA) with Near Infrared Spectroscopy technology (NIRS), capturing wavelengths between 670 and 810 nm. The monitor was positioned in the center of the designated patch (Figure 1), recording Mb and Hb levels post-sports liniment application and post-experiment. At the same time, the participants were in a supine position. The validity and reliability of this method have been confirmed, making it a suitable and accurate tool for measuring muscle oxygen levels in sports settings.[19,26]

Muscle strength

Muscle strength was evaluated using a Lafayette handheld dynamometer (01165A, Lafayette, Indianapolis, USA), measuring in kilograms (kg). Knee extension and hip flexion tests were conducted with one leg secured to the plinth, and three measurements were taken to calculate the mean score. The study compared the results of the tests performed without the sports liniment and with the application of 3 mL of sports liniment. During the tests, stabilization with a belt on the non-dominant leg showed reliable outcomes for assessing knee and hip strength. It is advisable to have consistency in examiners to avoid discrepancies in results, emphasizing the importance of using the same tester throughout the evaluations.[27]

Isometric hold during 95° hip flexion

Participants in the study were required to lift kettlebells weighing 8 kg, 10 kg, or 12 kg from the floor using their foot, achieving a hip flexion angle of 95° as

measured by a handheld goniometer. The participants were instructed to maintain this position for as long as possible, with the "Time to Failure" stopwatch recording the duration in seconds. The stopwatch was immediately stopped if participants exhibited backward leaning or dropped their hip below 90° of flexion. Each participant underwent this test once per day, totalling two tests throughout the protocol. Previous research has suggested that isometric tests can provide insights into the muscle's oxygen saturation levels.[21]

Statistical analysis

A descriptive statistical analysis was conducted to investigate the impact of tape stripping and massage interventions on various dependent variables among four participants divided into two groups. Each participant received 3 mL of Namman Muay on the rectus femoris muscle of their dominant kicking leg. The dependent variables included skin temperature, myoglobin, and hemoglobin levels, as well as isometric strength tests for hip flexion and knee extension and an isometric endurance test measuring the time to failure of the hip flexor in the dominant leg.

The analysis compared measurements taken on Day 1 (pre-intervention) with those on Day 2 (post-intervention). The study focused on calculating the differences in each dependent variable between the two days to assess the effects of the interventions. Descriptive statistics were utilized to present the changes observed in each variable on both days, offering a comprehensive summary of the outcomes.

Results

In this case study, the baseline characteristics Table 1 revealed that 4 male Muay Thai fighters were recruited, with an average age of 34.5 years old, height of 1.65 meters, weight of 65.6 kg, and BMI of 23.95 kg/m^2. No participants left the study. Table 2 reveals ST between the TS and MG groups, with temperatures decreasing within groups from Day 1 to Day 2 after applying 3 mL Namman Muay. The results of Mb and Hb oxygen percentile levels without NM (Day 1) and with 3 mL NM (Day 2) show that Mb percentage levels increased in both TS participants (64.0 to 78.85% and 79.28 to 86.00%); however, only 1 participant in the MG group (78.28 to 86.71%). The mean increase in the TS group was 10.78, while the MG group was 7.56. The Hb percentage reported in Table 2 also shows that the mean MG group value observed a slight increase of 0.57, while the TS group observed a slight decrease of 0.88 after 3 mL NM was applied.

Table 3 depicts the variations in hip flexion strength between Day 1 (NM) and Day 2 (NM) across the 3 mL TS and MG groups. The findings indicate that the TS group observed more significant increases with a mean value of 2.47 kg, while the MG group's mean was 0.65 kg. Table 3 also shows the Isometric endurance test time to failure (TTF) observing increases on Day 2 compared to Day 1, with the TS group reporting a mean increase of 37.33 sec (30.52 and 44.14), while the MG group observed a mean rise of 66.43 sec (64.84 and 68.03).

Table 1. Participants baseline characteristics (N=4).

Participant	No. 1	No. 2	No. 3	No. 4	Mean
Age (years)	33	30	31	44	34.5
Height (cm)	163.0	167.0	159.0	173.0	165.0
Weight (kg)	62.2	64.0	57.2	78.9	65.6
BMI (kg/m^2)	22.6	23.4	23.4	26.4	23.95

Note: *These are the characteristics of the four participants who were Muay Thai fighters with an observation that participant No.4 is not consistent with other three participants.*

Table 2. Physiological outcomes differences in skin temperature (°C), myoglobin (%), and hemoglobin (%) between the tape stripping group (N=2) and massage group (N=2).

Physiological outcome tests		Day 1 No treatment				Day 2 Treatment Tape stripping (TS) or massage (MG) with 3 mL Namman Muay [change]			
		No.1	No. 3	No. 2	No. 4	No. 1 (TS)	No. 3 (TS)	No. 2 (MG)	No. 4 (MG)
Skin temperature (°C)	Pre	36.8	35.6	34.8	34.9	32.5	33.2	32.3	34.9
	5-min Post	35.1	35.2	35.5	36.7	32.3	32.5	32.9	33.8
	Post (End)	35	34.9	35.7	36.7	32.6	32.4	31.8	33.9
Myoglobin, Mb % (Post end test)		64.00	79.28	86.57	78.28	78.85 [+14.85]	86.00 [+6.72]	85.7 [-0.87]	86.71 [+8.43]
Hemoglobin, Hb % (Post end test)		12.55	12.17	11.84	11.71	11.57 [-0.98]	12.27 [+0.1]	11.91 [+0.2]	12.21 [+0.5]

Table 3. Physical outcomes reporting mean testing values, Tape stripping group (N=2) and Massage group (N=2) without Namman Muay and 3 mL of Namman Muay.

Physical outcome tests	Day 1 No treatment				Day 2 Treatment Tape stripping (TS) or massage (MG) with 3 mL Namman Muay [change]			
	No. 1	No. 3	No. 2	No. 4	No. 1 (TS)	No. 3 (TS)	No. 2 (MG)	No. 4 (MG)
Hip flexor strength (kg)	9.9	10.1	11.1	13	13.3 [+3.4]	12.1 [+1.5]	11.8 [+0.7]	13.6 [+0.6]
Knee extension strength (kg)	8.2	9.8	7.3	9.2	8.5 [+0.3]	10.23 [+0.4]	7.3 [0.0]	9.8 [+0.6]
Isometric (Time to failure, sec)	17.2	21.9	26.3	22.2	47.71 [+30.52]	66.04 [+44.14]	91.14 [+64.84]	90.23 [+68.03]

Discussion

The results of this case study suggest the potential benefits for Muay Thai fighters when 3 mL NM is used as part of the warm-up training. The two mechanical enhancers used to promote penetration of the liniment, massage (effleurage) and tape stripping, could be challenged in a real-life situation, with massage being the more likely method to be used.

The ST was a surprise, with a lack of increases being observed after the interventions, in particular within the massage group due to the friction of massage exerting pressure on the stratum corneum, assuming an increase in both skin temperature and enhancing the distribution of the API or Transppenedgeal across the skin pathway would take effect.[28,29] Elevating skin temperature through a warm-up routine before engaging in physical activities has garnered support from numerous studies that underscore its performance enhancement and injury prevention advantages.[16-18] The physiological benefits of warming up are substantial, as it triggers changes in the body that prime it for exercise. A key effect is the elevation of muscle temperature, which boosts muscle elasticity and diminishes the risk of injuries. This temperature increase can also optimize metabolic processes, ultimately improving performance outcomes.[30] Furthermore, the skin and muscle temperature escalation during warm-up enhances muscle function, including increased muscle contractility and quicker reaction times. Research has demonstrated that higher temperatures can elevate the rate of force development and enhance overall muscle performance, which is particularly crucial in sports that necessitate explosive movements like Muay Thai.[31]

Sports liniments containing Methyl Salicylate and L-Menthol being applied before warm-ups may have an inhibitory effect on increases in skin temperature due to their vasodilatory effects, the body's response to cold, altered sensory perceptions, and potential impacts on muscle activation.[5,32] In practice, the inhibition of skin temperature increases can significantly affect athletic performance, increase injury risk, and alter psychological readiness. The penetration of methyl salicylate first acts on the enzyme cyclooxygenase by inhibiting it. This prevents prostaglandin and thromboxane A2 from reacting as inflammatory mediators and counteracting the increase in skin temperature. Increasing skin temperature has beneficial effects; however, as seen in this case study,

reducing skin temperature may be counterproductive. Athletes and coaches should be mindful of these effects when incorporating topical sports liniments containing methyl salicylate and L-menthol into their routines. Future studies may consider increasing the liniment dosage and a more extensive study population to ascertain whether this raises skin temperature.

The potential impact of sports liniment containing methyl salicylate and L-menthol on muscular myoglobin levels has not been extensively studied. However, the vasodilatory properties of these compounds could improve blood flow to muscles. This enhanced perfusion may lead to increased oxygen delivery, indirectly affecting myoglobin levels.[5] The protein myoglobin binds and stores oxygen, and when Muay Thai fighters begin to perform, oxygen is delivered to these muscles. Helping muscles to contract further and produce energy. However, if the intensity is too high or lasts too long, the muscles may not receive enough oxygen from myoglobin, leading to fatigue and injury.[19] If the APIs in NM can increase myoglobin, this will benefit Muay Thai fighters. The TS group's mean increase was 2.45 kg after 3 mL NM with methyl salicylate reacting to the muscle to increase blood flow.[33,34] This value may have a significant clinical effect on the hip flexor strength among Muay Thai fighters, stability, and agility while also playing a role in injury prevention.

Hemoglobin saturation levels were negligible, which was an unexpected outcome. Hemoglobin levels tend to remain steady during physical performance, such as Muay Thai fights, due to several physiological mechanisms that regulate oxygen transport and utilization in the body. Factors contributing to this stability are adaptations to training: Over time, athletes develop physiological adaptations that enhance their ability to utilize oxygen efficiently. These adaptations include improved muscle oxidative capacity and increased capillary density, which facilitate better oxygen extraction from the blood, thereby allowing hemoglobin levels to remain stable even during strenuous activity.[35]

Muay Thai fighters require various subcategories, including maximal endurance and explosive strength. The specific demands for these types of strength depend on the intensity, duration, and frequency of muscle contractions during training and competition.[36] A study found no significant differences in knee extension strength when measured in a seated position, raising questions about this testing position's effectiveness. It was suggested that measuring knee extension strength in a supine position with the knee flexed at a 10° angle might yield different results.[37] As aforementioned, the rectus femoris muscle may yield atypical strength values [13,14,38] due to its unique anatomical and functional characteristics. Effectively addressing the atypical nature of the rectus femoris when measuring strength values and standardizing the testing protocol helps to mitigate against inconsistent, unreliable, and invalid measurements. This reflects the muscles' dual role as hip flexor and knee extensor are considered and managed.[39]

The application of sports liniments containing the compounds Methyl Salicylate and L-Menthol, again with limited previous research on muscular strength implications, may be attributed to a combination of vasodilation, pain relief, enhanced muscle activation, improved breathing comfort, and psychological benefits.[5,43] Regarding hip flexion strength, both groups in the study showed increases, with the TS group demonstrating a significant increase of 2.45 kg compared to 0.65 kg in the other group. This indicates that the TS group had a more significant improvement in hip flexion strength. The tape stripping technique is a non-invasive method that effectively removes the stratum corneum, which consists of three significant lipids that form a barrier on the skin.[8,9,40] This barrier can impede the absorption of substances, but tape stripping enhances skin permeability, possibly allowing for better results in strength training applications. In contrast, the massage technique used in the study required a pressure of no more than 25 kPa to achieve similar increases in skin permeability.[41]

The isometric endurance strength test showed significant results: The TS group mean increased its holding ability to 37.33 seconds, while the MG group increased its holding ability to 68.03 sec. All participants used an external mass of 17% of their body mass (low intensity) and sustained the isometric holding force to exhaustion with 80% to 100% voluntary muscle contraction. Variables such as muscle mass size can be expected to favor one participant over another, especially in weight-categorized sports such as Muay Thai. Lower muscle mass may be able to sustain an isometric contraction longer, as larger muscles require more oxygen and energy to maintain contraction. MG group, penetration of the APIs, was the last performance test, so the Methyl Salicylate should be effective now. This increases SmO_2, which correlates with an increase in strength.[19,21] Future studies may want to include measurements of the muscle being explored, thereby observing whether muscle mass correlates with any increase or decrease in muscular endurance capability.

Muscular strength and endurance increase can be attributed to various physiological mechanisms. Sports liniments are formulated with ingredients that promote vasodilation, resulting in increased blood flow to the muscles. This improved circulation enhances oxygen delivery and nutrient supply to the muscle tissues, thereby supporting enhanced performance and quicker recovery.

Moreover, many liniments possess analgesic properties that help relieve pain and reduce muscle stiffness. This can contribute to a more fantastic range of motion and strength, particularly in hip flexion activities.[42] When liniment is applied with massage, it can boost neuromuscular activation. This synergy enhances the communication between the nervous system and muscles, ultimately improving muscle contraction and strength output during movements.[43] The effects of sports liniment are typically immediate, offering a short-term performance enhancement. This quick boost can be especially advantageous in sports, where athletes must rapidly optimize their strength and flexibility before competitions or training sessions.

The present study is the first to apply sports liniment

to Muay Thai fighters' physiological and athletic performance outcomes. Secondly, the study design as a case study allowed the experienced Muay Thai fighters to compare baselines with their intervention. Finally, field testing devices were high-precision instruments that enabled the validity and reliability of data collection. The study was not without limitations. Firstly, the trial duration was short at 35 minutes, which may have limited the effect of permeation of the API into the underlying tissues.[44] A more extended period of 90 minutes is recommended to allow for an impact and is realistic for a Muay Thai fight or training duration.[45] Secondly, the dosage form was limited to only 3 mL NM. Lower or higher dosage forms may result in either less, better, or equal results, one recommendation being 1 mL and 5 mL.[46] Participants' nutritional and hydration status was not considered or recorded, which should be regarded as due to possible correlations with impaired hemoglobin levels.[47] However, it is essential to note that this study had a small sample size and relied on descriptive analysis, limiting the generalizability of the findings to other populations. The descriptive nature of the analysis also restricts the ability to establish causal relationships or underlying mechanisms. While this type of research is valuable for exploratory purposes, future studies with larger sample sizes, control groups, and more sophisticated analytical methods are necessary to validate or challenge the results of this study.

Conclusion

This case study indicates that sports liniment may positively impact physiological outcomes such as increasing oxygen myoglobin percentages and specifically enhancing muscular strength and endurance when applied to the hip musculature as part of the warmup in Muay Thai. The use of tape stripping may enhance the permeation of the sports liniment into the underlying tissue more effectively, potentially further increasing myoglobin within the muscle.

Conflicts of Interest

The authors declare no conflict of interest.

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