



THE EFFECTS OF IMAGERY ON MUSCLE PERFORMANCE AND PAIN PERCEPTION ASSOCIATED WITH DELAYED-ONSET MUSCLE SORENESS

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ABSTRACT

Research has indicated that imagery may aid in recovery from injuries and reduce the perception of pain in athletes during and after competitions. There is little research concerning acute pain and soreness, such as delayed-onset muscle soreness (DOMS). The purpose of this investigation was to determine whether the use of guided imagery for healing will affect soreness, pressure pain threshold (PPT), and muscle performance associated with DOMS. It was hypothesized that those who listened to a healing imagery script following inducement of DOMS would report less soreness, higher pain threshold, and have better muscle performance than a control group. Participants (thirty-eight) completed two days of testing with 48 hours between them. At the end of the first day, DOMS was induced by performing 6 sets of 15 reps of isokinetic eccentric exercise at -1.05 rad/sec. 20 participants listened to a healing imagery script 10 times within the 48 hours after inducement of DOMS while 18 listened to relaxing music. Each day consisted of tests of soreness, PPT, vertical jump, and a Wingate test. Healing imagery had no significant impact on perception of soreness, PPT, or vertical jump. The healing imagery group performed significantly better than the control group on the Wingate test in minimum power and power drop results following DOMS. Thus, it appears that imagery could impact long duration anaerobic performance as opposed to short duration explosive performance. Further research is needed to determine if healing imagery can improve performance on longer anaerobic and possibly aerobic activities. Additionally, it is possible that the limited exposure to the imagery in this investigation limited its ability to impact muscle performance and pain perception.

Keywords: Imagery, Pain, DOMS, Recovery, Healing, Wingate, Vertical jump.

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Contribution/ Originality

The paper's primary contribution is the finding that healing imagery following inducement of DOMS improves anaerobic endurance performance while having no impact on perception of pain and vertical jump.

1. INTRODUCTION

Pain can be a major detriment to athletic performance. Kress and Statler (2007) explained that pain during performance can be a product of factors such as an uncomfortable heart rate level, lactate build-up, depletion of glycogen and dehydration. It has been suggested that effective mental strategies, which aid the athlete in tolerating higher levels of pain during their performance, predict better performance from the athlete (Kress and Statler, 2007). One such strategy is imagery, which has been shown to expedite the process of injury rehabilitation, increase pain tolerance, improve performance and even lessen a participant's perception of pain (Alden *et al.*, 2001; De Pascalis and Cacace, 2005; Driediger *et al.*, 2006; Kress and Statler, 2007). While the research investigating the effects of imagery on pain is promising, significant questions remain.

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Imagery is the act of cognitively producing an object or scene as if it were in reality (Driediger *et al.*, 2006). Within the definition of imagery, there are many different types that can be examined such as guided imagery, positive and negative imagery, and internal and external imagery (Alden *et al.*, 2001). Guided imagery is a type of cognitive strategy employed to reduce responses to unpleasant stimuli, such as pain or anxiety, and consists of healing mental images involving all of the senses. The individual's image can be either positive or negative, depending on the internal dialogue used, the outcome of their image and whether or not those are denoted positive or negative. The focus of the imagery can be either specific to the body part that is experiencing pain such as imaging the quadriceps healing (internal), or completely external to the body, such as in videos showing a healing protocol such as icing (Alden *et al.*, 2001).

Thompson (1981) suggests that imagery may reduce the participant's report of pain and increase the participant's threshold and tolerance of pain. Specifically, cognitive control strategies, such as imagery, change an event from unbearable to one that can be endured (Thompson, 1981). Imagery has been shown to enhance endurance performance by way of distraction and reducing the perception of pain (Cymerman *et al.*, 1983; Kress and Statler, 2007). Cymerman *et al.* (1983) examined imagery's effect on endurance performance and found that those who employed the cognitive strategy of imagery were able to endure the same level of discomfort for a longer period of time when compared to a control group. Kress and Statler (2007) also attempted to understand the effects of imagery on Olympic cyclists' experience when using some type of cognitive strategy during performance. The majority of athletes commented on their use of imagery as a tool to manage pain and prepare for races. These studies suggest that the use of a cognitive strategy, namely imagery, can have positive effects on pain and the perception of pain, ultimately reducing the pain's effect on performance.

Although numerous authors have attempted to explain the effects of imagery on a variety of definitions of pain, there is little known about imagery concerning muscle soreness and delayed onset muscle soreness (DOMS). DOMS is muscle soreness that can be felt one to two days after a day of intense exercise. This phenomenon is associated mostly with eccentric contractions, which are presumed to cause structural damage in the muscle tissues. One of the effects of DOMS is a reduction in the force-generating capacity of the muscles that are damaged. Therefore, if a strategy were developed to reduce the perception of DOMS and increase the force-generating capacity of the muscles, there could be tremendous benefits for both athletes and non-athletes.

The purpose of this investigation was to determine the effects of guided imagery on muscle performance and pain perception with delayed-onset muscle soreness. Based on the literature, which suggests that imagery can have a positive impact on pain and performance, it is hypothesized that imagery will have a positive effect on muscle function and perception of pain such that participants in the imagery group will demonstrate better muscle function and a lower perception of pain following DOMS compared to a control group. The imagery group is also hypothesized to experience less fatigue than the control group during the performance tests.

2. METHODS

2.1. Participants

A convenience sample of 41 participants enrolled in the study. In this total were 19 males and 22 females all of college-age and physically active and healthy. During the first day of testing, the participants were provided an informed consent that met the approval of the institution's Review Board. For participant demographic information see table 1.

Table-1. Participant Demographic Information

	Male (19)		Female (22)	
	Mean	SD	Mean	SD
Age	20.3	0.9	21.3	2.1
Height (cm)	180.1	8.1	167.2	5.8
Weight (kg)	84.2	15.7	64.9	6.2
Body Comp (% Fat)	15.0	6.9	24.0	4.3

2.2. Measures

2.2.1. Pain Measures

2.2.1.1. Muscle Soreness Questionnaire

The participant was asked to rate their soreness on a scale from 1 (normal) to 10 (very, very sore). The participant indicated their soreness for the front and back of the right thigh.

2.2.1.2. Pain Pressure Threshold

Pain pressure threshold was measured using a dolorimeter. The dolorimeter was calibrated in kg/cm² with a range of 11 kg with 100g divisions. Consistent with previous research, pain pressure threshold was measured using the following steps. First, an explanation was made to the subject such as the following; "I am going to measure pressure threshold, that is, how much pressure will induce discomfort. I am going to increase pressure slowly with this device. Say "Yes" when you start to feel pain or discomfort. I will stop the pressure as soon as you say "Yes" so it will not hurt you (Keele, 1954; Fischer, 1986; Fischer, 1987). It is important that you understand that this is a test of sensitivity, not a test of endurance (Cirelli, 1964). Do you understand or have any questions?" After the explanation was made, the rubber tip of the dolorimeter was placed exactly over the middle of the muscle being measured with the shaft at a 90° angle. Pressure was increased continuously 1 kg per second until the subject says "Yes" (Keele, 1954; Merskey and Spear, 1964; Fischer, 1986; Fischer, 1987). All measurements were taken from the right lower extremity. Higher numbers represented a higher pain pressure threshold. One examiner completed all measurements in order to decrease the need for inter-rater reliability.

2.3. Performance Measures

2.3.1. Vertical Jump

Vertical jump was assessed using the Just Jump mat (Probotics, Huntsville, AL), which calculates jump height in inches according to time spent in the air. Participants were advised to use a counter-movement before their jump, but to not take a step, as well as to land back on the mat. The participant performed 3 trials each day of testing. The peak and average height of the three jumps were recorded and used for analysis.

2.3.2. Wingate Anaerobic Power Test

The Wingate anaerobic power test is a cycle test designed to assess a subject's peak anaerobic power, relative peak anaerobic power, total work and fatigue index (Ayalon *et al.*, 1974). The test requires the participant to pedal as fast as possible for 30 seconds against a resistance equivalent to .075 kg per kg of body weight. Peak power is calculated based on the power output of the first 5 seconds of the test. Relative peak power is obtained by dividing the peak power by the weight of the participant. Total work is the amount of work accomplished over the 30 seconds. The fatigue index is calculated by subtracting the lowest 5 seconds of peak power from the highest 5 seconds of peak power and dividing by the highest 5 seconds of peak power and then multiplying by 100.

2.4. Procedures

On the first day of testing, participants came to the lab and were given an overview of the procedures and provided informed consent. Participants then completed a packet of questionnaires, which included: demographics and the muscle soreness questionnaire. Following the completion of the questionnaire packet, pain pressure threshold measurements with the dolorimeter were made at the approximate midpoint of four muscles; vastus lateralis, vastus medialis, medial head of the biceps femoris, and lateral head of biceps femoris.

The remaining performance tests were then administered in order from least fatiguing to most fatiguing. Participants were given 10 minutes to warm up on a stationary bicycle and then complete the vertical jump test and the Wingate anaerobic power test. Following completion of the Wingate test, subjects were given 5 minutes to

recover and then the delayed onset muscle soreness (DOMS) protocol was administered. DOMS was induced by performing six sets of 10 repetitions of eccentric knee extension/flexion exercise at $-1.05 \text{ rad} \cdot \text{sec}^{-1}$ bilaterally. The participant was given 30 seconds between each completed set as well as a minute rest in between the third and fourth sets. These exercises were completed on the Biodex System 2 Isokinetic Dynamometer. After inducing DOMS, the control group was given a USB drive with just relaxing music while the imagery group was given a USB drive with the imagery script. Both groups were told to listen to the audio track a total of 10 times between the first and second days of testing. The imagery script consisted of relaxing background music and a narrator instructing the subject through an imagery session designed to interfere with the pain felt from the DOMS procedure.

The second day of testing took place 48 hours following the first day to ensure maximal muscle soreness. The procedures for day two were the same as day one with the exception of the informed consent, demographic variables, and DOMS procedure. Participants were asked to complete the muscle soreness questionnaire, the pressure threshold measures, the vertical jump test, and the Wingate anaerobic power test. Following completion of the Wingate test, subjects were debriefed and thanked for their participation.

3. RESULTS

3.1. Muscle Soreness Questionnaire

A 2 (group) by 2 (time) ANOVA with repeated measures on the time factor indicated a significant time main effect for the front of the leg, $F(1, 39) = 28.73, p < .001$ and the back of the leg, $F(1, 39) = 62.69, p < .001$, such that both groups reported an increased amount of soreness on day two (see table 2).

Table-2. Muscle Soreness Questionnaire*

	Pre Front	Post Front	Pre Back	Post Back
Imagery (n = 20)	1.57 ± 0.8	2.71 ± 1.6	1.33 ± 0.5	4.14 ± 1.3
Control (n = 20)	2.00 ± 1.1	3.61 ± 2.3	2.00 ± 2.2	4.70 ± 2.7

* All findings showed significant time main effect

3.2. Dolorimeter

A 2 (group) by 2 (time) ANOVA with repeated measures on the time factor revealed a significant time main effect in the lateral portion of the back of the leg, $F(1, 39) = 6.84, p = .013$, such that both groups had a lower pain threshold in this area on day two. There was also a significant group effect, $F(1, 39) = 4.28, p = .045$, such that the control group had a higher overall threshold compared to the imagery group (see table 3).

Table-3. Pain Pressure Threshold

	Pre Front	Post Front	Pre Back	Post Back
Imagery				
Medial	3.50 ± 1.4	3.45 ± 1	4.01 ± 1.2	4.18 ± 1.4
Lateral	4.87 ± 1.6	4.63 ± 1.6	4.81 ± 1.3*	4.69 ± 1.3*
Control				
Medial	4.39 ± 1.4	4.24 ± 1.5	4.86 ± 1.8	4.57 ± 2
Lateral	5.42 ± 1.5	5.22 ± 1.9	6.17 ± 1.9*	5.61 ± 2.6*

*Findings showed significant time main effect and group effect

3.3. Performance Measures

3.3.1. Vertical Jump

A 2 (group) by 2 (time) ANOVA with repeated measures on the time factor revealed no significant group, time, or group by time interaction for the vertical jump measure.

3.3.2. Wingate Anaerobic Power Test

A 2 (group) by 2 (time) ANOVA with repeated measures on the time factor revealed a significant group by time interaction for minimum power in watts, $F(1, 39) = 4.18, p = .048$. Paired samples t-tests revealed that the imagery group had higher minimum power following treatment ($t(21) = 2.42, p = .025$) while the control group did not change ($t(18) = .421, p = .679$) (see figure 1). Additionally, a group main effect was observed for power drop, $F(1, 39) = 4.42, p = .042$ such that the imagery group had a smaller power drop than the control group (see figure 2).

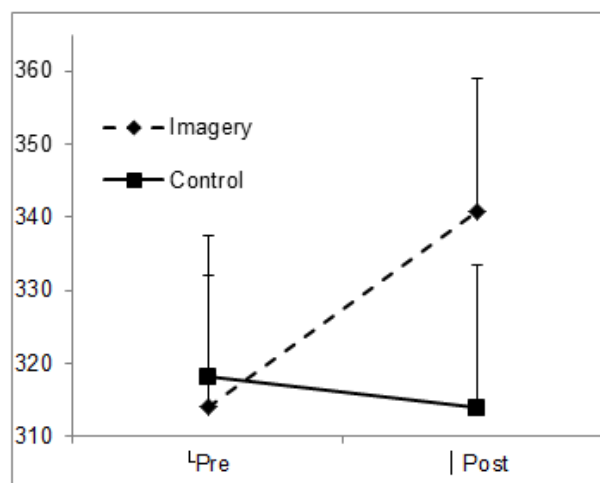


Figure-1. Wingate Minimum Power (Watts)

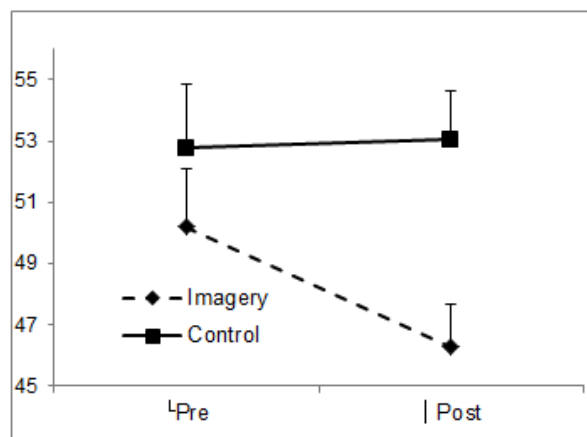


Figure-2. Wingate Power Drop (%)

4. DISCUSSION

The purpose of this investigation was to examine the effects of guided imagery on pain perception and performance associated with delayed-onset muscle soreness (DOMS). Exercise-induced DOMS appears 12-48 hours after strenuous exercise and is localized to the area most strained during the activity (George *et al.*, 2007). Guided imagery is the process of recreating healing images using one's imagination and involving all of the senses (Kwekkeboom, 2000).

Overall, the results partially support the hypotheses, which indicated that the use of imagery would have a positive effect on the participant's perception of pain and they would also have a higher level of muscle function and therefore perform better as compared to the control group. The results varied between each of the performance measures, suggesting that the impact of imagery may be different depending on the task.

4.1. Muscle Soreness Questionnaire

There were no differences between the control and imagery group on perceptions of pain. The questionnaire did support the effectiveness of the DOMS-inducing protocol in that the participants, as a whole, were significantly sorer on the second day of testing.

4.2. Pain Pressure Threshold

It was hypothesized that the imagery group would experience a higher pain pressure threshold than the control group on the second day of testing. Using the dolorimeter, there were no significant differences between the groups on their levels of pain pressure threshold. There was a significant time effect for both of the groups, indicating that the DOMS-inducing protocol caused the participants to experience a lower threshold for pain on the second day of testing. The results were most noticeable for the back of the leg, indicating that the hamstring muscles experienced a greater degree of DOMS. Overall, the results from the dolorimetry and muscle soreness questionnaire counter findings in previous research (De Pascalis and Cacace, 2005; Menzies *et al.*, 2006; Kingston *et al.*, 2007) all of whom found a significant positive influence of imagery on pain perception and pain tolerance. Menzies *et al.* (2006) found that patients diagnosed with fibromyalgia returned to a better functional status and were better able to deal with the pain associated with their disease following imagery sessions. Kingston *et al.* (2007) concluded that pain tolerance significantly improved for their participants who were introduced to imagery practice. De Pascalis and Cacace (2005) echo these findings in that their study resulted in an effective reduction of pain following the use of mental imagery. This contradiction between the literature and the current results could be due to the short interval between testing days, not allowing the participant to fully practice the imagery. The studies cited above used multiple imagery sessions over a period of weeks. Also, the participants were advised to listen to the script ten times between testing sessions, but we were unable to closely monitor the amount of times they did listen to the script.

4.3. Vertical Jump

The results from the vertical jump test did not reach significance, but did follow a trend that would support our hypothesis. It was predicted that the imagery group would have a higher vertical jump as compared to the control group on the second day of testing due to better muscle function as a result of the imagery intervention. The results show that the control group stayed relatively the same in mean jump height from day 1 to day 2, whereas the imagery group showed a small increase in their average jump height; however, this failed to reach statistical significance.

4.4. Wingate Anaerobic Power Test

The results from the Wingate anaerobic power test provided the most support for the hypothesis. It was hypothesized that the imagery group would perform better on this 30-second test due to their lower perception of soreness and better muscle function as compared to the control group. For minimum power, which was measured in Watts, the imagery group had a higher amount of power when compared to the control group, indicating that they were able to provide more power at the end of the 30 seconds than the control group (refer to figure 1). These results were echoed by the power drop percentage results, a factor that indicates how much the participant dropped from their peak power at the beginning of the 30 seconds. The imagery group had less of a power drop than the control group on the second day of testing (refer to figure 2). This indicates that the imagery group was able to

maintain their level of power for a longer amount of time than the control group. It is also important to note that the imagery group did not experience a statistically significant drop in their amount of peak power. This furthers the idea that the imagery group experienced better muscle function seeing as their change in power drop and minimal power was not a result of a decrease in peak power, but rather an increased ability to maintain performance levels. These results would imply that the imagery may have its greatest effect on those activities that require a certain amount of endurance as opposed to pure power.

4.5. Limitations

A main limitation of the current study was distributing the imagery script. The participants were asked to listen to the script 10 times, but it was impossible to confirm that they adhered to this request. Another limitation was that the participants only had 48 hours to learn the script, which might not be enough time to learn imagery skills to employ in the performance tests. Also, a large majority of the participants in the study were athletic and performed physical activity on a regular basis, which would imply that they are accustomed to the feelings and result of exercise-induced DOMS. This familiarity could have affected their performance on the second day of testing as they are used to performing with a certain amount of soreness. It is unclear the effects this study would have if used on a non-athletic population.

4.6. Future Direction

Studies in the future concerning the effects of imagery on pain perception and performance following exercise-induced DOMS could focus on testing longer-duration anaerobic activities or activities that create more tension in the muscles to see if there is a difference in imagery's effects. The current study found that more significant findings were consistent in activities that required some sort of anaerobic endurance. Future investigations could determine whether there is a difference in the effects of imagery on anaerobic endurance compared to aerobic endurance. Furthermore, future studies could examine whether the type of physical activity performed mediates imagery's positive effects following exercise-induced DOMS. Also, investigations could change the population of focus to one that is more sedentary in order to determine imagery's effect on DOMS for those who are not as familiar with the soreness and pain associated with DOMS. This could have important implications to help initiate exercise programs for sedentary people who are hesitant due to the DOMS experience.

4.7. Summary

The results concerning the effects of healing guided imagery on DOMS and pain and performance as a result of DOMS are altogether varied. There is some support for the findings described by [Olsson *et al.* \(2008\)](#) that suggest imagery has a positive effect on performance. Also, the results indicate some validation for [Thompson \(1981\)](#) theory that imagery can be used as a cognitive strategy that changes an activity from unbearable to one that can be endured. While there seems to be a positive effect of imagery on longer-duration anaerobic activity as shown by the Wingate anaerobic power test, more research needs to be done in order to make these findings conclusive. The vertical jump results displayed a trend as seen with the absolute numbers, but the relationship between groups failed to reach significance. Again, more research would need to be done in order to solidify or refute these conclusions. As for the results with the pain threshold and muscle soreness measures, they both prove that our DOMS protocol was effective and elicited soreness in both the quadriceps and hamstrings. Also, the participants' threshold for pain decreased in the front and back of the leg, both medially and laterally. Our results show little support for the research previously conducted on imagery with pain levels and perception of pain. This may be due to the structure of the design of the studies in that most of the interventions were of longer duration, allowing the participants to become familiar with the imaging process ([De Pascalis and Cacace, 2005](#); [Menzies *et al.*, 2006](#); [Kingston *et al.*, 2007](#)).

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REFERENCES

- Alden, A.L., J.A. Dale and D.E. DeGood, 2001. Interactive effects of the affect quality and directional focus on mental imagery on pain analgesia. *Applied Psychophysiology and Biofeedback*, 26(2): 117-126.
- Ayalon, A., O. Inbar and O. Bar-Or, 1974. Relationships among measurements of explosive strength and anaerobic power. In RC Nelson and Morehouse (Eds). *International series on sport sciences, Biomechanic IV*. Baltimore: University Press, 1: 572-577.
- Cirelli, M.G., 1964. Clinical experience with bromelains in proteolytic enzyme therapy of inflammation and edema. *Medical Times*, 92(9): 919-922.
- Cymerman, A., D.H. Horstman, W.P. Morgan and J. Stokes, 1983. Facilitation of physical performance by means of a cognitive strategy. *Cognitive Therapy and Research*, 7(3): 251-264.
- De Pascalis, V. and I. Cacace, 2005. Pain perception, obstructive imagery and phase-ordered gamma oscillations. *International Journal of Psychophysiology*, 56(2): 157-169.
- Driediger, M., C. Hall and N. Callow, 2006. Imagery use by injured athletes: A qualitative analysis. *Journal of Sport Sciences*, 24(3): 261-271.
- Fischer, A.J., 1986. Pressure threshold meter: Its use for quantification of tender spots. *Archives of Physical Medicine and Rehabilitation*, 67(11): 836-838.
- Fischer, A.J., 1987. Pressure algometry over normal muscles: Standard values, validity, and reproducibility of pressure threshold. *Pain*, 30(1): 115-126.
- George, S.Z., G.C. Dover and R.B. Fillingim, 2007. Fear of pain influences outcomes after exercise-induced delayed onset muscle soreness at the shoulder. *Clinical Journal of Pain*, 23(1): 76-84.
- Keele, K.D., 1954. Pain-sensitivity tests: The pressure algometer. *Lancet*, 266(6813): 636-639.
- Kingston, J., P. Chadwick, D. Meron and T.C. Skinner, 2007. A pilot randomized control trial investigating the effect of mindfulness practice on pain tolerance, psychological well-being, and physiological activity. *Journal of Psychosomatic Research*, 62(3): 297-300.
- Kress, J.L. and T. Statler, 2007. A naturalistic investigation of former olympic cyclists cognitive strategies for coping with exertion pain during performance. *Journal of Sport Behavior*, 30(4): 428-452.
- Kwekkeboom, K., 2000. Measuring imaging ability: Psychometric testing of the imaging ability questionnaire. *Research in Nursing & Health*, 23(5): 301-309.
- Menzies, V., A.G. Taylor and C. Bourguignon, 2006. Effects of guided imagery on outcomes of pain, functional status, and self-efficacy in persons diagnosed with fibromyalgia. *Journal of Alternative and Complementary Medicine*, 12(1): 23-30.
- Merskey, H. and F.G. Spear, 1964. The reliability of the pressure algometer. *British Journal of Social and Clinical Psychology*, 3(2): 130-136.
- Olsson, C.J., B. Jonsson and L. Nyberg, 2008. Internal imagery training in active high jumpers. *Scandinavian Journal of Psychology*, 49(2): 133-140.
- Thompson, S.C., 1981. Will it hurt less if i can control it? A complex answer to a simple question. *Psychological Bulletin*, 90(1): 89-101.

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