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The Influence of Mental Imagery on Myofascial Restrictions

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ABSTRACT: Mental imagery (MI) has been shown to influence flexibility when used with stretching. Currently, little evidence supports the efficacy of MI as an independent tool to increase flexibility. Therefore, the purpose of this investigation was to assess if a guided MI protocol could influence subject range of motion (ROM) measures. Thirty individuals with no history of lower limb injuries underwent initial measures, random group assignment, and post-intervention measures. The imagery group followed a guided visualization of a hamstring stretch, and the control group remained still for the same amount of time. No significant group by time differences were found between the two groups for any of the recorded measures. Although statistical significance was not demonstrated, a post hoc power analysis showed a small effect size on the ANOVA test for knee extension. This study shows that an acute MI-only protocol may not positively influence ROM measures in the hamstring musculature. Future work should use familiarization periods to determine if a learning effect is related to the efficacy of an MI protocol to influence flexibility and validated imagery assessment methods. Future work should also utilize different musculature and stretches to determine if visualization has a uniform influence globally and if different stretch variations may be more efficacious in influencing flexibility.

KEYWORDS: mental imagery; visualization; flexibility; hamstrings

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INTRODUCTION

Athletes, professionals, and individuals from the general population require flexibility and fluid range of motion (ROM). A lack of functional ROM increases these populations' likelihood of injury (Doğan et al., 2019; Sexton & Chambers, 2006). To find novel and efficient ways to boost flexibility and ROM, previous studies have examined the combination of mental practice with physical training (Guillot, Tolleron, & Collet, 2010; Williams, Odley, & Callaghan, 2004). Mental practice or mental imagery (MI) is the act of mentally visualizing the performance of a specific task without physically participating in that task.

Previous research shows that brain regions activate similarly when performing a task and visualizing or thinking about performing that same task (Ranganathan, Siemionow, Liu, Sahgal, & Yue, 2004). A study of MI's ability to increase strength in a finger abduction training protocol found that, in a comparison of three groups, the group that visualized performing finger abduction increased their finger abduction strength by 35% (Ranganathan et al., 2004). The physical training group who physically performed finger abduction increased strength by 53%. Conversely, the control group showed no significant change in finger abduction strength (Ranganathan et al., 2004). The increases in finger abduction strength through MI imply that mental training alone can produce strength increases similarly to strength training, at least for the hand musculature. The nervous system plays a role in the demonstration of strength (Jenkins et al., 2017), which is a factor related to the increases in strength through mental training alone, as seen in the previous research (Ranganathan et al., 2004).

Additionally, the nervous system also contributes to flexibility through signaling mechanisms. For example, the changes in flexibility due to muscle relaxation when stretching is performed, is in part due to Golgi tendon organ function (McAtee & Charland, 1999). Because nervous system regulation contributes to increased flexibility and can influence strength through MI alone, it may be possible to influence flexibility through independent MI (McAtee & Charland, 1999; Ranganathan et al., 2004). Stretching methods such as proprioceptive neuromuscular facilitation (PNF) stretching involve changes in nervous regulation and can increase ROM acutely through reciprocal inhibition (Sharman, Cresswell, & Riek, 2006). Investigating if independent MI can elicit similar reduced activation by antagonistic muscle groups may allow for the development of a novel method to increase ROM acutely and further explain increases in flexibility from PNF stretching. It is important to note that the changes found by Ranganathan et al. occurred over 12 weeks, where subjects trained 15 minutes a day for five days each week. Currently, few studies show significant changes acutely in ROM measures using an MI protocol. Previous evidence shows that it is possible to produce a physical and meaningful impact on measures such as strength through MI (Ranganathan et al., 2004); other research has shown similar results in other measures, including muscle activation (Lebon, Guillot, & Collet, 2012). Research has also found that significant gains in flexibility can occur when physical training protocols are combined with MI protocols (Guillot et al., 2010; Williams et al., 2004). It is important to note that the previous investigations occurred throughout five weeks and three weeks respectively, and the protocols for the latter were administered throughout 15 sessions (Guillot et al., 2010; Williams et al., 2004).

Currently, it is unclear whether the mechanism by which imagery influences outcomes impacts flexibility directly or if it is related to a placebo effect which could explain previous findings. Mental rehearsal may inherently relax or prime the body for a change, which may explain increases in flexibility. Positive expectations and the placebo effect may play into physiological and physical changes that have been presented in previous research. However, for therapy purposes, positive expectations could be beneficial for patients, helping to ease the therapy process.

Previous investigations have explored the effects of imagery on body segments such as the quadriceps, hip muscles, hamstrings, shoulders, and ankles, but few studies address whether these tools work uniformly across all muscle groups (Guillot et al., 2010; Lebon et al., 2012; Williams et al., 2004). Different muscle groups vary in their structure, function, and neural networking. As a result, imagery and visualization may affect musculature in variable ways and thus produce different outcomes for a given procedure. The current investigation seeks to determine if mental imagery could acutely and independently influence physical measures including myofascial length and muscle tone in the hamstring muscle group.

MI has shown to influence strength and increase

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flexibility measures (Guillot et al., 2010; Ranganathan et al., 2004; Williams et al., 2004). However, few recent studies investigate the use of MI as an intervention to influence flexibility.

METHODS

Participants

This study was IRB approved through the University of Central Florida IRB (IRB Study 00000107). The present investigation enrolled a total of 30 subjects (43.3% female) with a mean age of 21.7 years a two-armed trial (15 individuals per group). The test groups consisted of an imagery group and a control group.

Participants were recruited through the population of the University of Central Florida. To participate, individuals had to be between the ages of 18 and 65 and fully recovered from or have no history of lower limb injury that would influence hamstring flexibility.

Participants could not have a current development of pathology in the hip, knee, thigh, or low back. Further, participants recovering from an injury in a lower limb that would affect hamstring flexibility were also excluded. Individuals with any of the following criteria were also excluded from participating in the study: pain in lower limbs or lumbar spine, current use of a relaxant medication, inability to consent, pregnancy, and incarceration.

Procedures

The trial evaluated the effects of two different conditions on hamstring flexibility. Individuals were randomly assigned to one of the test groups; all individuals were involved in flexibility and ROM assessment before testing, and measures were assessed with long-arm goniometers.

Throughout the study, from when the subjects completed initial measurements to when the post-intervention measures were taken, the subjects remained in a supine position, with their hips and knees bent to 90 degrees as measured by an investigator before resting the participant's legs on a platform. Subjects were maintained in a constant position to allow for more precise visualization of the stretch, to limit subject movement, and to reduce the likelihood of error.
Measurements collected from test groups included ROM measurements and a mental imagery assessment, these measures were collected in a manner similar to that used in previous research (Decoster, Scanlon, Horn, & Cleland, 2004; Prather et al., 2010; Williams et al., 2004). The equipment used to perform measurements included long-arm goniometers to take flexibility measures, which have been found to be reliable in previous investigations (ICC > 0.95 for intra-rater reliability and ICC > 0.85 for inter-rater reliability; (Brosseau et al., 2001; Hancock, Hepworth, & Wembridge, 2018; Watkins, Riddle, Lamb, & Personius, 1991), sleeping masks and noise-reducing headphones to limit outside sensory stimuli and to play the guided imagery audio, and lastly, an adjustable platform where subjects placed their legs. Three investigators collected all measures in the experiment. To limit bias, the two researchers conducting the ROM measurement protocols exited the room while the remaining investigator had subjects conducting imagery procedures, including initial visualization and intervention implementation.

Randomization

Individuals enrolled in the study were randomly assigned to groups using an envelope system where subjects could choose an envelope containing either the number one or two. If a subject chose the envelope with the number one in it, they were placed in the control group, and if they choose an envelope with the number two, they were placed in the intervention group. The subject then was either taken through the intervention or control protocol. After the respective intervention was provided, the subject was instructed to refrain from telling the investigators what intervention the subject received.

Pre-Intervention Measures

The measurements collected were taken from whichever leg the subject used to kick, which was considered the dominant leg (Williams et al., 2004). A support system was used to standardize hip flexion during measurements at a constant 90 degrees during both measuring sessions.

Hamstring Measurement

To assess hamstring flexibility, subjects were asked to move into a supine position on the examination table, then to move into 90-degree hip and knee flexion. Once subjects were in position, an investigator would mark the lateral malleolus, lateral femoral epicondyle, and the line of the greater trochanter of the femur. One researcher

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maintained the anterior and posterior position of the thigh to maintain the hip angle. Subjects maintained 90 degrees of hip flexion and then were asked to extend the knee as far as possible. Once subjects reached terminal knee extension or hip flexion integrity began to falter, another researcher measured the angle of knee extension, which was rounded to the nearest tenth of a degree. Measurements were taken identically before and after the protocol. This test was previously found to be reliable (ICC = 0.899 for intra-rater reliability; (Decoster et al., 2004); (see Figure 3).

Vividness of Imagery

A protocol adapted from previous research was used to gauge how readily participants could perform visualizations (Williams et al., 2004). Subjects were shown the hamstring stretch they would visualize, and after the demonstration, they were asked to close their eyes and visualize the stretch. The demonstration of the hamstring stretch before visualization occurred through three modes. First, the investigator displayed two images: one of an individual in the initial supine position with ninety degrees of hip and knee flexion and an image of an individual in the final position of terminal knee extension. Next, the investigator verbally described the process to achieve the stretch. Finally, the investigator physically demonstrated and described the process of conducting the stretch. Subjects were given thirty seconds to visualize the demonstrated stretch and were asked to rate their ability to perform the visualization based on if they were able to see and feel themselves performing the stretch. Subjects rated their visualization on a scale of 0 to 9 where 0 meant they could not visualize the stretch, and 9 meant they could clearly see and feel the hamstring stretch (Williams et al., 2004).

Interventions

Intervention group

Subjects were shown the hamstring stretch before visualization through the same three modes used during the vividness of imagery assessment. The stretch consisted of subjects lying down with 90 degrees of hip flexion (Figure 1). Subjects imagined maintaining 90 degrees of hip flexion and then imagined actively extending the knee as far as possible (Figure 2); (Decoster et al., 2004). Subjects were instructed to visualize the stretch on the earlier identified dominant leg based on the instructions of a pre-recorded guided visualization audio script.

The pre-recorded script was used to standardize the procedure and provided subjects with cues to move through an exact visualized stretch. Participants were told to visualize the demonstrated stretch and to refrain from physically conducting the stretch. The visualization period lasted 3 minutes and 15 seconds. The imagery group underwent ROM measures before and after the intervention.

Control

Control group individuals solely underwent ROM measures before and after their waiting period in the testing room, which was equivalent to the time it took the intervention subjects to complete visualization (3 minutes and 15 seconds). Participants were also placed in the supine position with ninety degrees of hip flexion. The measures collected from the control group were compared to the other test group.

Figure 1: Intervention group setup

Figure 2: Visualized hamstring stretch

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Figure 3: Hamstring measurement

Statistical Analysis

The statistical analysis plan included the evaluation of descriptive statistics and frequency counts. Inferential statistics included independent and dependent student t-tests and a repeated measure analysis of variance (ANOVA). A post hoc statistical power analysis was also conducted for the ANOVA to verify power and effect size for the primary variable of knee extension.

RESULTS

Subjects were randomly placed into either the guided visualization group (imagery) or the control group. The analysis of baseline demographics showed no significant differences between groups for sex, age, height, weight, and leg dominance (Table 1). There were also no significant differences between groups at baseline for knee extension measures (Table 2).

Terminal knee extension measures (TKE) were significantly different in the control group between pre-

	Control Group	Imagery Group	Overall	P-value
Sex (% female)	15 (40%)	15 (46.7%)	30 (43.3%)	0.71
Age Mean (SD)	20.67 (3.04)	22.73 (5.47)	21.70 (4.49)	0.22
Height Mean (SD)	66.00 (3.4)	66.33 (3.94)	66.17 (3.63)	0.81
Weight Mean (SD)	152.23 (29.90)	146.40 (25.60)	149.31 (27.51)	0.57
Leg Dominance (% left)	3(20%)	3(20%)	6(20%)	1.0

Table 1: Demographic data of participants

	Control Group (N=15)			Imagery Group (N=15)				
	Pre-interventi on (SD)	Post-interventi on (SD)	P-value (within-group)	Pre-interventi on (SD)	Post-interventi on (SD)	P-value (within-group)	P-value (Between groups at baseline)	P-value (group-by time interaction)
Knee Extension	154.3° (7.3)	156.8° (6.8)	.007*	153.3° (10.4)	156.4° (5.0)	.106	0.75	0.74

SD: Standard Deviation

° - degrees

Table 2: Pre and post intervention outcome measures based on group

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intervention (mean TKE=154.3°) and post-intervention measures (mean TKE = 156.8°) ($p < 0.01$) and non-significant in the imagery group (pre-intervention mean = 153.3° and post-intervention mean = 156.4°); ($p = 0.11$); (Table 2). A repeated-measures ANOVA demonstrated that there was no significant group by time differences found between the imagery and control group for the knee extension measure (Table 2). Finally, a post hoc power analysis demonstrated a small effect size and power (3% and 5%, respectively); (Faul, 2007).

DISCUSSION

An important consideration of the current investigation's outcomes is that this study evaluated the effects of MI as an independent modality to influence flexibility. Conversely, the majority of other studies utilize some form of stretching or intervention together with MI to measure the combined impact of those interventions.

Another factor to consider is that previous investigations looking at the impact of imagery on flexibility have occurred over a significantly longer period (Guillot et al., 2010; Williams et al., 2004), while the purpose of the current study was to see if MI could increase ROM acutely. The intervention and preparation for the intervention of the current study took only about 30 minutes, excluding time for questions and consent. We could find no literature describing the length of time it takes for MI to begin producing significant results in increases in flexibility, or if MI as a standalone intervention can produce increases in range of motion. While not empirically proven, it may be possible to extrapolate that a learning effect is necessary for those attempting to use MI to produce increases in any measure. Essentially, for increases in measures such as strength and flexibility to occur, an individual must be familiar with visualization. This factor could explain the positive findings by other, significantly longer studies which allowed subjects to become familiar with imagery, among other procedures. Previous findings may agree with the idea of a learning effect, since projects have chosen to place the "best-imagers" into the imagery group after taking the initial assessment of imagery abilities (Guillot et al., 2010). Utilizing subjects with existing knowledge and understanding of how to visualize may play a role in the significance of previous findings. However, previous research has demonstrated no relationship between participants' imagery ability and increases in flexibility (Guillot et al., 2010).

Guillot et al. previously discussed the necessity of familiarity with the procedures and effectiveness of MI. In their previous investigations, imagery groups demonstrated better outcomes compared to the control group for a front split flexibility measure ($p = 0.03$), with mean flexibility increases of 8.9 cm and 4.73 cm, respectively. Similar outcomes have been shown in a hamstring stretch exercise ($p = 0.035$), with mean increases of 2.7 cm for the imagery group and decreases of 0.63 cm in the control. However, Guillot et al's. research also demonstrated no significant differences for the shoulder and side split stretches ($p = 0.73$ and $p = 0.08$ respectively). The investigators explained that these outcomes could be due to the subjects' unfamiliarity with the side split and shoulder flexibility stretches. The participants did not regularly practice the shoulder and side split stretches and therefore may have had trouble producing those mental images (Guillot et al., 2010). The individuals enrolled in the current study were not surveyed to see if they regularly practiced the hamstring stretch that we employed. Lack of familiarity with procedures may help explain why the imagery group did not produce significant results, as the subjects may not have been able to produce the necessary mental imagery.

Researchers have postulated that imagery used for increases in range-of-motion acts as a medium which allows users to experiment mentally with how the act of stretching will occur. Additionally, this method could promote or compound increases that are initially produced by stretching (Williams et al., 2004). The present investigation included control and "imagery-only" groups. The results of the imagery-only group show that visualization occurring independently of stretching in an acute phase produced no enhancements in ROM; this result may suggest that imagery functions primarily as an "attentional device" to enhance increases in range of motion facilitated primarily by stretching.

Researchers in previous studies selected the "little finger abductor" and elbow flexors to test the impact of imagery on strength (Ranganathan et al., 2004). While not directly related to the current investigation, the results of the imagery used in this study compared to the current project may elucidate the possibility that MI, as an independent intervention, may be more appropriate for smaller musculature involved in fine movement patterns. The current project chose to see if a larger muscle mass (the hamstrings) could be influenced by MI to increase flexibility measures. This difference in muscle size may contribute to our lack of significant findings. It was

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postulated that the difference in findings on various MI studies could be due to size and neural factors, including the fact that there are fewer muscle fibers per motor unit in muscles that produce fine movement patterns that allow for intricate movements (Ranganathan et al., 2004).

The data from this investigation suggests that a guided audio visualization did not seem to significantly influence hamstring length as measured by the TKE assessment (knee extension $p = 0.11$). While both groups showed no significant differences in baseline demographics, the control group showed significant differences in knee extension when compared to baseline ($p < 0.01$). Since both groups underwent the same measurement protocol and showed no significant difference for baseline knee extension, it would be expected that both would produce similar outcomes if the product of the increased knee extension was a result of the stretching inherent to the measurement protocols. However, since only the control group demonstrated a significant difference in TKE, there likely exists another explanation for this result.

The current investigation's evidence did not provide support that independent MI could elicit reduced activation of antagonistic muscle groups, leading to acute increases in ROM. A possible explanation for the difference in significance between groups and the lack of acute increases in flexibility in the MI group may have to do with muscular excitation. Research suggests that MI may produce excitatory effects in individuals who are unfamiliar with imagery and procedures (Ranganathan et al., 2004), which might result in the development of muscular tension. This excitatory effect may explain why the difference in outcomes between groups in this current study, as the control group's waiting period may have acted as a relaxation period that led to a reduction in muscular tension. Conversely, the imagery group's intervention period may have produced an increase in tension due to the novel stimulus to the participants. From the current investigation's evidence, it is uncertain if MI can reduce activation by antagonistic muscle groups.

LIMITATIONS

Limitations of this study include the possibility of statistical error due to project design. These confounding factors include the brevity of the investigation, lack of physiological measurements, participant familiarity with procedures, and potential construct validity issues with the imagery protocol and stretch selection procedures. Additional bias could have been introduced by the novelty of the measurement techniques utilized in the study, including the goniometry and measurement protocols, to the researchers collecting the measurements. Bias could also have been introduced during initial ROM measurements by raters' knowledge of the subjective confidence of the subject's imagery ability. The initial vividness of imagery measure procedure which was adapted from a previous study (Williams et al., 2004), has not been verified or tested for validity by any other investigator and therefore, there is uncertainty of the method's reliability to give an accurate measure. Given the uncertainty of the reliability of the intial vividness of imagery scores, subjects may have rated their visualization ability higher than their actual ability. Better imagery abilities may be necessary for MI to work as an independent intervention. One can also see error through the post hoc power analysis conducted for this study; a posthoc power analysis demonstrated a small effect size and power (3% and 5% respectively); (Faul, 2007).

Future work should use single variable testing combined with imagery to assess changes in subject's perception of flexibility. This design could elucidate if positive expectations or a placebo effect can influence flexibility measures. Future investigations should also include orientation periods to promote subject familiarity with imagery and related procedures to account for a possible learning effect that may be needed for imagery to be effective. Another consideration for future work would be utilizing more specific and validated imagery methods such as the VMIQ-2 or its adaptations (Callow & Roberts, 2010; Roberts, Callow, Hardy, Markland, & Bringer, 2008). Finally, future work should test different body segments that vary in size and motor function (gross versus fine) and use different stretches to assess whether visualization and MI can influence these measures and if they do so uniformly across the body.

CONCLUSIONS

The current investigation finds that there is uncertainty whether MI and visualization can be used independently to influence acute ROM measures. The current investigation also finds that the use of MI to primarily influence hamstring flexibility measures produced non-significant results. Future research will be necessary to examine the efficacy of imagery's ability to influence flexibility measures. More investigation is needed to

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conclude if imagery is beneficial as an independent tool for improving flexibility in other body regions and musculature by utilizing different stretching or visual protocols alongside specific project design.

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