
Pramod D Shenoy MPT *

**ABSTRACT**

It is well established that motor imagery (MI) improves motor performance and motor learning efficiently. Previous studies provided evidence that muscle strength may benefit from MI training, mainly when movements are under the control of large cortical areas in the primary motor cortex. The purpose of this experiment is to assess whether MI might improve upper and lower limbs’ strength through an ecological approach and validation, with complex and multi-joint exercises. Nine participants were included in the MI group and 10 in the control (CTRL) group. The 2 groups performed identical bench press and leg press exercises. The MI group was instructed to visualize and feel the correspondent contractions during the rest period, whereas the CTRL group carried out a neutral task. The maximal voluntary contraction (MVC) and the maximal number of repetitions (MR) using 80% of the pre-test MVC weight were measured. Although both MI and CTRL groups enhanced their strength through the training sessions, the leg press MVC was significantly higher in the MI group than in the CTRL group (p< 0.05). The interaction between the leg press MR and the group was marginally significant (p = 0.076). However, we did not find any difference between the MI and CTRL groups; both in the bench press MVC and MR. MI-related training may contribute to the improvement of lower limbs performance by enhancing the technical execution of the movement, and the individual intrinsic motivation. From an applied and practical perspective, we state that athletes may perform imagined muscles contractions, most especially during the rest periods of their physical training, to contribute to the enhancement of concentric strength.

**Key words:** mental imagery, motor imagery, mental practice, sports rehabilitation, athletic training, strengthening.

**Authors’ information:**

* - Corresponding author. pramodshenoy80@gmail.com

Lecturer & clinical instructor, Dept of Physiotherapy, School of Therapeutic Sciences, Masterskill University College of Health Sciences, Selangor, Malaysia.
of this experiment, the methodology and results. But there is still no mention about the population that was studied, though the results of the study were implied to the athletic population.

**INTRODUCTION**

The way in which the authors introduced the research to the reader deserves appreciation. It had clear statements of the context and general background of the study, comprehensive and up-to-date critical reviews of the relevant literature, rationale for why a further piece of such research was necessary, and stating an unambiguous research hypothesis with an expected outcome.

**METHODS**

**Experimental approach to the problem**

The study design adopted was very appropriate to study the research question i.e. the causal relationship between motor imagery (independent variable) and the muscle strength (dependant variable). The use of outcome measures such as maximal voluntary contraction (MVC), the maximal number of repetitions (MR) and anthropometric measures was also appropriate to study the variable under consideration. Although some researchers may argue and suggest the use of torque measurement as an outcome measure of muscle strength, such measurements need expensive, cumbersome isokinetic equipment and trained technicians, posing practical difficulties. The means of measurement employed by the authors are clinically more relevant and also can be carried out at other clinical set-up.

**Subjects**

The ethical issues involved in this experimental study are acknowledged by the authors and they mention the approval of the institute research committee and written informed consent from the volunteers obtained before its conduct.

With such an ideal design used to study the effect of motor imagery on muscle strength, it was important that the authors "matched" the subjects in each group. The two groups should have been identical in every respect other than the intervention, to add credibility to the study results. Although random allocation of subjects to the groups served some purpose of matching, there was no mention on how the authors performed it.

With so many subject factors present, that may influence the outcome measures, the authors mention only the mean age of the groups. Other factors such as gender, BMI or body size, fitness level, motivation & stress levels, involvement in recreational sports during the study duration, diet and nutritional status time of day of testing etc. also could have influenced the results. The subjects were also not similar with respect to their competitive sport. It would have been possible to eliminate or control at least some of these confounding factors by setting up criteria for inclusion or exclusion of subjects to improve the study’s internal validity. Though the authors mention the sample studied, it is not mentioned how the sample size was calculated for the 95% confidence interval set for analysis. Sample size calculation appropriate for the study design is important to overcome errors in hypothesis testing (type I and type II). The three subjects failing to complete the program, as reported by the author, may further adversely affect the study results.

Author does mention that the subjects were blinded to the study purpose which again is important in any experimental trial. However, prior to mentioning subject allocation the author states- “Before the experiment, none of the participants specifically performed MI with the aim of improving motor performance. They were therefore given detailed instructions to perform imagery accurately and efficiently.” Does this mean that the control group was also told about the motor imagery training? Since the subjects were not allowed to choose the group they would want to be, there was no need for the authors to educate the control group on MI.

**Procedures**

It was a good approach by the authors to evaluate the individual differences (MI group) in visual and kinesthetic movement imagery using a 7-point Movement Imagery Scale.
questionnaire, and also to describe the questionnaire for better understanding of the reader. But whether the subjects with poor scores were to be excluded at this point is not discussed.

The author gives a good description of the measurements performed, the protocol used for testing and training, the frequency and duration of the training, rest periods within and between sessions, all in detail and well tabulated. But any reference to this protocol being previously used or being useful in strength training is not quoted anywhere in the text. The reader at this moment may question the validity of this protocol for strength training. [It is very much possible that some subjects were easily fatigued than the rest, or some subjects report fatigue during bench press than with sled leg press, since the subjects were not matched to their physical fitness levels or the sport (soccer players or tennis players). How the authors decided to overcome this problem was not clear. Were they allowed to discontinue or were they allowed to take more rest?]

It is very clear from the description how the bench press and sled leg press movement were performed. The sled leg press movement is also pictorially presented for better understanding of the reader.

After instructing the participants on using MI, the authors made sure they performed the correct type of imagery by asking them to rate the ease/difficulty encountered to accurately form the mental representation of movement on a 6-points likert scale. This was a very good move to ensure uniformity in MI during the training.

At no point does the author report about calibration, reliability or validity of these measurements used.

**Assessment of MI use**

The author writes – “There was a significant difference between the 12 sessions, the first and the last MI evaluation session being 4.13 (0.56) and 5.09 (0.82) respectively. The participants estimated that they were thus more able to form accurate images of their movements at the end of the experiment.” But the author also states in the procedure for same measurement that “1= very easy to imagine/feel and 6= very difficult to imagine/feel (2,3,4,and 5 being intermediate levels.” These two statements contradict each other. Also for a mean score of 4.66 mentioned, the participants were finding it more difficult to imagine/feel the visual or kinesthetic imagery. So it can be very well questioned, whether the MI group was really benefited with this type of training which is also not further discussed by the author as a limitation of this study.

**RESULTS**

**Strength Performances**

It is again very clearly and concisely stated; with analysis of each outcome measure studied i.e. MVC, MR and anthropometric measures. For the ease of understanding the results are represented in tables and graphically (both within group and between group comparisons).
differences in sled leg press MVC. The theoretical explanation holds no good since there was no difference between the two groups with respect to bench press MVC. Moreover, the observed difference could have been due to the methodological issues and limitation of the present study which is nowhere acknowledged by the authors while discussing the findings. However, no results are omitted from the discussion, nor are wild claims made for the use of this intervention for muscle strengthening. Also, authors identify the need for further research involving other muscle group essential to ascertain the efficacy of MI included in applied strength training and to understand its underlying mechanism.

REFERENCES
References are numbered, clear and appropriate.

OVERALL CONSIDERATION
Given the importance of strength training in athletes, this study was valuable in implicating the use of motor imagery to enhance it, thereby improving their performance or hastening recovery after injury. The reader could also assess the suitability of the research design to address the research question. However, there are threats posed to the study’s internal validity. Hence the methodological issues and limitations of the study (as mentioned in appropriate section) should be considered before judging the results and their implication.

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CONFLICTS OF INTEREST
None identified.

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OTHER INFORMATION
The corresponding author of the appraised article- Aymeric Guillot, is available at aymeric.guillot@univ-lyon1.fr.

Key points:

Past- Motor imagery was a part of psychotherapeutic techniques used for relaxation and stress management, also used in chronic pain states.

Present- Motor imagery was effective to improve muscle strength in athletes in maximum voluntary contraction during leg press.

Future- Evidence of effectiveness for motor imagery on muscle strength in other muscle groups and comparisons with other methods of training is lacking. Electromyography (EMG) studies during motor imagery or functional magnetic resonance imaging (f-MRI) would probably provide answers in near future.