

Original Article

The improvement effect of limited mental practice in individuals with poststroke hemiparesis: the influence of mental imagery and mental concentration

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Abstract. [Purpose] This study examined whether limited mental practice improves the motor performance of poststroke individuals with hemiparesis. [Subjects] Twenty-three participants with poststroke hemiparesis (40–82 years of age) participated in this study. [Methods] The subjects were divided into four groups with respect to a dart-throwing task: the no-practice, physical practice only, mental practice only, and mental and physical practice groups. The groups were compared in terms of gains in motor performance, mental imagery vividness, and level of concentration during mental practice. [Results] No statistically significant difference was found for gains in motor performance among groups, and there was no correlation between imagery vividness and motor performance gains. However, a correlation was found between gains in motor performance and mental concentration during mental practice. [Conclusion] The results suggested that limited mental practice for individuals with poststroke hemiparesis may not improve motor performance. However, a higher degree of concentration during mental practice may improve motor performance.

Key words: Mental practice, Imagery vividness, Mental concentration

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INTRODUCTION

In the rehabilitation of individuals with poststroke hemiparesis, a physical therapist verbally instructs, guides, and aids in the repetitive practice of movements and motions. However, when there is a significant reduction in overall physical functioning in addition to motor function, it has been found that such repetitive practice can be a cause of both fatigue and reduced motivation for rehabilitation¹⁾. Meanwhile, research in sports training has shown that combining mental practice with physical practice enhances the effects of training relative to physical practice alone^{2–5)}.

Mental practice is defined as a method of using mental imagery to rehearse the performance of a task without engaging in observable physical practice^{6, 7)}. The effects of mental practice are determined by factors such as the characteristics of the learner and the task, practice conditions, learning stage, and type of mental practice^{8–11)}. From the little research that has been done on learner characteristics, findings indicate that intelligence does not need to be above average but that the ability to form mental imagery does af-

fect learning. As for task characteristics symbolic tasks are more suited to mental practice than motor tasks, and it has been found that the effect of mental practice is greater for easy tasks that require small muscle control than for complicated tasks. Research on practice conditions has shown that the most suitable period for mental practice is only a few minutes and that the effect of mental practice alone is smaller than the effect of actual physical practice. However, when combined with physical practice, the impact of mental practice is greater. As for the stage of learning and the type of mental practice, mental practice is believed to be more effective in the initial and intermediate phases of learning when the correct way of performing the task is understood and when appropriate feedback is given. Advantages of mental practice that have been suggested include the ability to understand subtle timings not noticed during physical practice, freedom from fear that may accompany physical practice, the ability to perform it with little fatigue, and the ability to perform it without limitations as to time and place^{9, 12)}.

Research has also found that combining mental practice with physical practice in the treatment of poststroke hemiparesis contributes to recovery from paralysis and reduces physical disability^{13, 14)}. Thus, integrating mental practice into rehabilitation can be expected to enhance its effects. However, most of the information regarding the effects of mental practice is based on studies in which mental practice was performed for periods of several weeks to several months^{15–17)}. Whether limited mental practice can contribute

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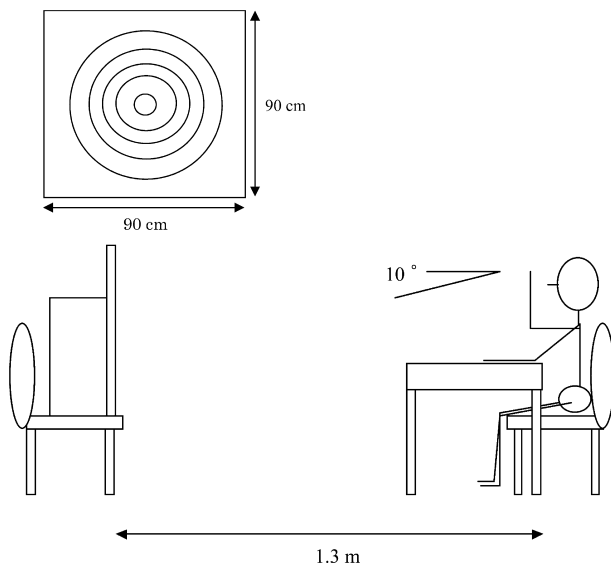


Fig. 1. Schematic view of the experimental task
The darts were thrown at a target located 1.3 m in front of the subjects. Subjects sat in an armless chair and threw 10 darts.

to motor performance improvement in poststroke individuals with hemiparesis is still incompletely understood. Thus, this study explored whether mental practice may improve the rehabilitation of these individuals. We assigned participants to mental and physical practice groups, in which they had to perform dart-throwing tasks, and measured the gains in (dart-throwing) motor performance. Further, the influences of the participants' vividness of mental imagery and the degree of mental concentration during mental practice on the gains in motor performance were studied.

SUBJECTS AND METHODS

Twenty-three people (40–82 years of age, 15 males and 8 females) participated in this study. Participants had paralysis in their dominant hand because of stroke and had no experience playing darts. Candidates were not included in the study if they had difficulties with active sitting, higher order brain dysfunction, visual field impairments, or orthopedic disorders in their nondominant arm.

The participants were randomly divided into four groups: a no-practice group, a physical practice group, a mental practice group, and a physical and mental practice group.

An outline of the dart throwing exercise can be seen in Fig. 1. Using off-the-shelf darts, a subject used his or her nondominant hand to throw darts at a target. The target was a 90 × 90 cm Styrofoam board with a black bull's-eye having a diameter of 10 cm surrounded by concentric circles 5 cm apart. Subjects were asked to sit on a four-legged chair with no arms, placing their dominant hand on the table and their legs in a comfortable position. The target was located 1.3 m away from the front of the subject's knees, and the bull's-eye was positioned 10° downward from the subject's eyes. In a procedure approved by the Internal Review Board of Hirosaki University, informed consent was obtained from

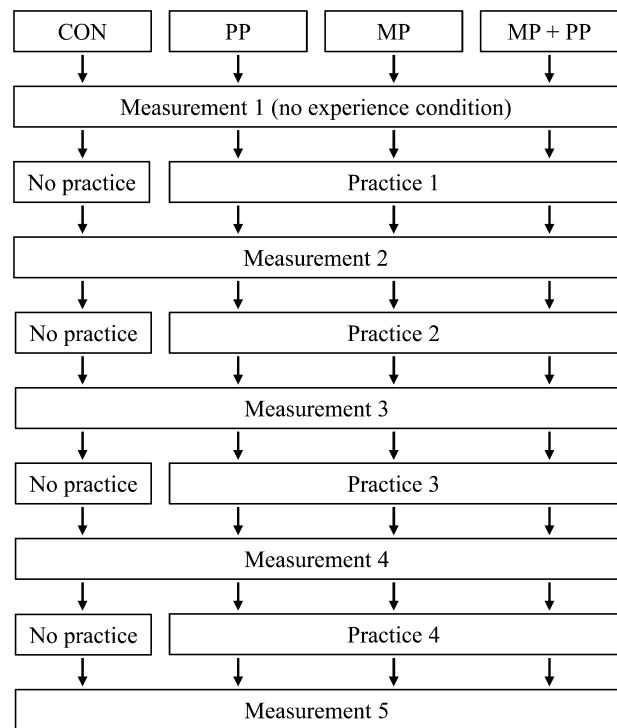


Fig. 2. Experimental procedure
Subjects performed mental, physical, or mental and physical practice, except for the subjects of the control group
CON: control group; PP: physical practice; MP: mental practice; MP + PP: mental and physical practice

each participant before the experiment began.

An outline of the experimental protocol is shown in Fig. 2. Before the experiment, we verbally explained the dart throwing position and dart throwing procedure. During throwing, subjects sat upright and put the non-throwing hand on the table. They flexed their shoulder and elbow joints 90 degrees and threw the dart toward the center of the target. Initially, subjects in all four groups each threw 10 darts without practice at the target's bull's-eye, and the distances from the bull's-eye were measured and tallied. This was followed by four rounds of the subjects' respective practice conditions followed by throwing and measurement (practice I → measurement I → practice II → measurement II → practice III → measurement III → practice IV → measurement IV), resulting in four practices and five measurements.

Regarding the practice conditions, the control group sat and rested for 2 minutes and 40 seconds (no practice). The physical practice group was asked to practice throwing 20 darts. The mental practice group had 2 minutes and 40 seconds of mental practice throwing darts. Finally, the physical and mental practice group had physical practice throwing 10 darts and 1 minute and 20 seconds of mental practice.

To measure motor performance, 10 darts were thrown one after another. Then, the distance from each hit to the bull's-eye was measured, and the measurements were tallied for a total score in millimeters. To measure the subjects' degree of mental concentration during mental practice in the mental practice group and the physical and mental practice group,

after each practice session, subjects were verbally asked to indicate their subjective feelings about whether they were able to concentrate completely (3 points), for the most part (2 points), or not at all (1 point). The vividness of each subject's mental imagery was tested with Betts' Questionnaire upon Mental Imagery (QMI) while the individual was seated with his/her eyes closed^{18, 19}. The data in this study were expressed as the mean \pm standard deviation, and a two-way factorial analysis of variance was performed followed by a Friedman test. The significance level was set at $p < 0.05$.

RESULTS

Although the trend in scores from better to worse was physical and mental practice group > physical practice group > no-practice group > mental practice group, the differences between the groups were not statistically significant.

However, correlational analysis showed that the correlation was not significant. The subjects' scores for vividness of mental imagery were concentrated between 60–105, with the larger portion being 80 or above. Therefore, the data suggested that the subjects' imagery vividness trended relatively high.

In the mental practice group and the physical and mental practice group, there was a statistically significant positive correlation between degree of mental concentration and gains in motor performance ($p < 0.05$) that is, the higher the concentration during mental practice, the more gains made in motor performance.

DISCUSSION

The results of this study showed no significant improvement in performance gains in the motor task after mental practice in the four groups (physical practice, mental practice, physical and mental practice, and no practice).

In previous research on mental practice related to upper extremity motor tasks, hemiparesis patients receiving neurodevelopmental therapy involving the performance of mental practice twice a week for six weeks showed improved motor functioning compared with those who only engaged in physical practice²⁰. In other research, it was reported that stroke patients receiving training in hand functions and performing mental practice for four weeks did significantly better on the Action Research Arm Test than those who completed physical practice alone²¹. Meanwhile, research on the effect of mental practice on gait rehabilitation has shown that individuals suffering from aftereffects of a stroke, who combined mental practice with walking practice for six weeks, demonstrated better improvement as indicated by the results of a 10-Meter Walk Test²². Research on the use of mental practice in rehabilitation has mainly employed tasks related to gait and the upper or lower extremities, and the results have shown that mental practice is effective in improving motor performance, regardless of the differences in each movement type. Therefore, it seems unlikely that the lack of a significant mental practice effect in the present study was related to the nature of dart throwing, a motor task of the upper extremities that entails voluntary movement of the fingers, hand, wrist, and elbow joints, and stabilization of

the trunk in a seated position while fixing the shoulder joints in a bent position. Thus, it is likely that influences from differences in the study's motor task requirements relative to other studies contributed only minimally to the difference in our results.

In mental practice research, there have also been studies on effective movement as a function of qualitative factors. According to Gaggioli et al.²³, mental practice was effective in improving coordination and step accuracy in female basketball players who practiced layup shots for four weeks based on the researchers' video analysis assessment of five factors: fluidity, rhythm, coordination, step accuracy, and balance landing. However, mental practice was not effective in improving fluidity, rhythm, or balance landing. Thus, in the present study, the lack of a mental practice effect may have resulted from the improvement effect being low for one or more of the underlying factors in the action of dart throwing, such as fluidity, rhythm, or coordination.

Furthermore, the absence of a mental practice effect in the present study could be attributed to the strikingly shorter mental practice period compared with other studies; for example, four weeks for balance training²⁴, six weeks for jumping performance in gymnastics²⁵, six weeks for poststroke patient walking practice²², four weeks for sit-to-stand and reaching-to-grasp movements²⁶, and 90 hours for shooting training²⁷. In addition, the sample in this study was small. One of the reasons for the obtained insignificant differences may be this small size.

Vividness of mental imagery is a measure of the extent to which mental images of objects are as clear as actual experiences of them. Betts' assessment of vividness of mental imagery employs images of ordinary scenes rather than imagery specific to games; however, it is known that in general, imagery vividness and gains in motor skill improvement are positively correlated^{28, 29}. However, in this study, vividness of mental imagery and motor performance were not positively correlated, perhaps because the subjects' imagery vividness assessments were uniformly high and differences among subjects were small.

Mental concentration in games is thought to reflect "the ability to focus on a single point in a state of relaxation, do one's best, and do so continuously"³⁰. In this study, it is reasonable to accept that the subjects' self-reported concentration levels during mental practice were sufficient for them to be able to relax and focus and do so continuously. It may be that the subjects' generally high abilities to form mental imagery enabled a high level of imagery vividness during their mental practice. However, although almost all subjects scored high in imagery vividness, it is reasonable to assume that because the results for the mental practice concentration levels varied, some subjects were not able to concentrate and, therefore, not able to imagine the task very well, while other subjects were able to concentrate and imagine the task clearly. Motor performance decreases with muscle and mental fatigue³¹. Repetition of dart throwing by subjects with no experience throwing darts led to muscle and mental fatigue and might have influenced performance progression and concentration during practice. Marcora et al.³² and Mehta et al.³³ reported that in the case of fatigue when the level of mental concentration is low, motor performance

declines. The present study suggests that when the duration of mental practice is short, mental concentration during mental practice may have a larger effect than vividness of mental imagery.

In conclusion, this study suggests that limited mental practice may not improve motor performance. However, increasing the amount of mental practice and concentration level during mental practice, rather than improving subjects' vividness of mental imagery, might improve motor performance.

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