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Effect of combined mental and physical training on the targeting accuracy of patients with multiple sclerosis

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Abstract

Multiple Sclerosis (MS) is a chronic disease of the central nervous system, and is cause of motor deficits and physical disability in young adults. This study aimed to determine the effect of combined mental and physical training on the targeting accuracy of patients with MS. This study was conducted on 41 patients with MS (31 women and 10 men) aged 20-50 years, the members of the MS society. The participants were selected through purposive sampling and were randomly divided into four groups of mental training (n=10), physical training (n=11), combined (mental-physical) training (n=11), and the control group (n=9). Dart throwing test was used to evaluate the targeting accuracy of the participants. Expanded disability status scale was used to measure the degree of disability in patients and vividness of movement imagery questionnaire-2 was used to assess the movement imagery ability. Training was performed for 8 weeks (three 15-minute sessions per week). Before and after 8 weeks, the participants. were tested on dart-throwing ability. The targeting accuracy of all training groups was significantly improved compared with the control group. A significant difference was observed in the level of improvement between the combined training group and other groups, but no significant difference was observed between the mental training group and the physical training group. Compared to other methods, combined mental and physical training can be more effective in improving the dart-throwing accuracy of MS patients.

Keywords: Accuracy, Mental, Multiple Sclerosis, Physical, Training

Introduction

Multiple sclerosis (MS) is a chronic progressive disease of the central nervous system and considered the third cause of neurological disability. It often occurs between the ages of 20 and 40 years, during which the patient's immune system shows an inflammatory reaction against its own nerve tissues and attacks the myelin sheath [1-2]. Currently, more than 2.5 million people worldwide and about 500,000 people in the United States have MS [3]. This disease is associated with impairment in daily activities [4] and 85% of these patients experience motor problems [5]. Fatigue is one of the main reasons why MS patients do not participate in physical activities [6]. Mental practice is an appropriate way for increasing the efficiency and is used as a supplement to physical exercises for improving skills and motor functions in patients [7,8].

Mental imagery is a type of mental practice and is defined as visualization or perceptual reconstruction of objects, movements, sights, and feelings as they are experienced in reality [7]. Mental practice facilitates the motor learning and can be partly transferred to similar tasks [9]. Physical and mental practices activate neural mechanisms involved in learning in the same way, so that the areas of the cerebral cortex involved in planning and motor control are also activated during mental practice [10] and the blood flow increases in the supplementary motor area [11].

Zimmermann-Schlatter et al. [10] reported that motor imagery can enhance the benefits of physiotherapy and occupational therapy in patients with stroke [10]. However, some findings are different and inconsistent in this regard. Researchers have shown that mental practice and motor imagery have no effect on motor recovery of patients after stroke and only strengthen their movement patterns [12]. On the other hand, a recent study reported that MS patients can improve their health by regular physical activity [13]; they can increase their cardiorespiratory fitness [14] and muscle strength [15], improve their quality of life [16], and reduce their fatigue which improve both physical and mental performance [17]. A cognitive activity such as accuracy can improve by physical training. Danski believes that neural mechanisms during processing information, including cognitive review of an activity while performing it in reality, as well as the autonomic system activity improve the individual's accuracy. Among the anatomical structures involved in this cognitive activity are premotor cortex, primary motor cortex, cerebellum, basal ganglia, and parietal lobe from the secondary motor area [18].

This study specifically aimed to examine the effect of mental and physical practices individually and their combination on the accuracy of MS patients. Some studies have reported a positive effect in this regard. Wichman & Mendoza [19] reported that teaching dart-throwing through mental training has a positive impact on dart-throwing performance. The results of studies in this regard are inconsistent. Hermans et al. [20] indicated that providing guidance and external symbols have no significant impact on the spatial accuracy of patients [20]. It has been found that the actual execution of movements and mental practice affect common areas of the brain [11]. Today, combined mental and physical exercises have been of interest to researchers.

Malouin et al. [11] examined the effect of combined mental and physical training on learning motor activities after stroke and indicated that mental training along with a small amount of physical training can play an important role in improving and re-learning motor activities of patients after stroke. Olsson et al. [7] showed that mental imagery combined with physical training significantly improve and can be used to improve vertical jump height. Combination of motor imagery and physical training has proved useful for the treatment of bradykinesia in patients with Parkinson [21]. Also, rehabilitation through mental trainings and usual rehabilitation through relaxation have a positive impact on improving the performance of patients with Parkinson [22]. Despite the potentials of mental and physical training for other neurological diseases, a few studies have examined the effect of mental and physical trainings on the performance of MS patients. Therefore, considering the beneficial effect of this type of training on the nervous-motor system, it is expected to be a useful method of rehabilitation for these patients. Thus, this study aimed to answer the question whether mental training or its combination with physical training can improve motor function of MS patients in dart-throwing skill considering that this skill requires targeting accuracy and motor coordination.

Method

This quasi experimental study was conducted on a study population of 101 patients with MS presenting to the MS society of Saqqez city, the west of Iran, in 2012. Given the special condition of this disease, only 63 of the patients were willing to participate in the study. All procedures of the research were approved by the Ethics committee of Islamic Azad University of Borujerd. In order to attribute the results of the study to the effects of the independent variable, 3.5 was considered the cut-off point for the Expanded Disability Status Scale (EDSS). Another inclusion criterion was obtaining the required score from the Vividness of Movement Imagery Questionnaire-2 (VMIQ-2) provided by Roberts et al. [23]. In this study, the subjects gained the required score from the VMIQ-2 (standard deviation± mean; 81.95±12.34). Therefore, according to these two requirements, finally 45 patients (34 women and 10 men) aged 20-50 years met the inclusion criteria and were selected for the study. They were randomly divided into 4 groups of mental training (11 participants), physical training (11 participants), control group (11 participants), and combined mental-physical training (12 participants). It should be mentioned that at least 2 years had passed since the diagnosis of MS in the subjects and none of them had experienced MS attacks during the 4 weeks before the start of the study. After completing the consent form, all subjects in each group were individually briefed on how the dart-throwing test would be administered. At first, they received necessary training on how to hold the dart, stand, position the feet, throw darts and set the elbow angle. Then, a pretest was administered, during which each participant threw 20 darts at the center of the dart board (the dart board with a diameter of 453 mm was installed in a way that the distance from the center of the board to the floor was 173 cm and the distance from the throwing line to the dart board was 237 cm). The distance between the place where the dart hit and the target center was recorded for each throw in cm. After excluding 5 throws with the highest error and 5 throws with the lowest error, the mean radial error of the 10 middle throws was calculated as the pretest score for each person. Then, the subjects trainingd for 8 weeks, three 15-minute sessions per week (totally 24 sessions) under the supervision of the researcher. It should be mentioned that 4 participants refused further cooperation due to the disease recurrence and unwillingness. Finally, 41 patients (10 participants in the mental training group, 11 participants in each of the physical training and combined (mental-physical) training groups, and 9 participants in the control group) continued participating. The mental training and combined training groups used Hickman method to get prepared for mental training [24]. According to this method, the individual lies down in a dim and quiet room without any stress. After mental preparation, he visualizes the dart board and based on the kinetic aspects of the operation (internal imagery), he imagines himself performing successfully, i.e., the thrown dart hits the bull's eye. The patients were instructed to position themselves as though they were performing the activity and visualize themselves in all positions that may happen during this activity.

The training program of each group was as follows: 1) the physical training group were supposed to perform physical training of throwing darts for 12 minutes (four 3-minute bouts). 2) After getting prepared based on Hickman method, the mental training group were supposed to perform mental training of throwing darts for 12 minutes (four 3-minute bouts). 3) After getting prepared according to Hickman method, the combined (mental-physical) training group were planned to perform mental training for 6 minutes and physical training for 6 minutes in four consecutive bouts (3 minute each bout). There was one minute rest between two consecutive bouts. 4) The control group did not perform any training and were involved in their everyday life during the training period. All patients in three training groups completed four bouts of throwing dart with 1 min rest between bouts. Hermans et al. [20] reported that some MS patients had impairment in accuracy and timing of motor imagery. Therefore, in this study, audio guides were given to patients during imagery to facilitate the timing and increase the accuracy of visualization. Three days after the last training session, a post-test was administered similar to the pre-test.

Statistical analysis was performed using SPSS-19. After examining the normality of data through the Kolmogorov-Smirnov test, the repeated measures ANOVA (4×2) was used to examine the intergroup differences. Bonferroni post hoc test was used to determine the point of difference. The paired t-test was used to examine the within group differences. The significance level was set as 0.05.

Results

The results of analysis of variance showed there was a significant difference in the targeting accuracy among the training groups ($F_{3,37}$=22.57, p=0.001). The Bonferroni post hoc test indicated that the radial error in the combined (mental-physical) training group was significantly decreased compared to the control group (p=0.001), mental training group (p=0.001), and the physical training group (p=0.12).

Table1 *Descriptive characteristics (age, height, and weight) of the participants in the physical training, mental training, combined training, and control groups*

Groups	Age (years)	Height (cm)	Weight (kg)
Physical training	35.5±8.718	179±6.5	79.5±5.4
Mental training	34.8±9.077	181±5.4	81.2±6.2
Mental-physical training	35.1±9.064	177±4.9	78.6±5.4
Control group	35.6±9.539	180±7.3	81.4±5.9

Also, a significant difference was observed between the physical training group and the control group (p=0.001), as well as between the mental training group and the control group (p=0.03). But there was no significant difference between the mental training group and the physical training group (p=0.44). (Table 2)

Table2 *Comparison of mean scores of throwing accuracy of MS patients before and after educational intervention in the combined training, mental training, physical training, and control groups*

Groups	Pre-test	Post-test	Intragroup p-value (paired t-test)	Intergroup p-value (ANOVA 4×2)
Mental-physical training	9.02±0.91	6.41±1.32*	p=0.002	p=0.001
Mental training	8.8±1.14	7.53±1.21&	p<0.001	
Physical training	8.59±1.38	6.79±0.97	p<0.002	
Control	8.54±1.28	8.33±1.51	p=0.25	

* Represents a significant difference with mental training, physical training and control groups
& represents a significant difference compared with the control group
p<0.001 was considered as the significance level.

the comparison of the mean scores of throwing accuracy of the MS patients before and after intervention in the combined training, mental training, physical training, and control groups using the repeated measures ANOVA (4×2) and paired t-test (both between and within groups). The results of the paired t-test indicated there were significant differences among the combined training group (t_{10}=4.20, p=0.002), physical training group (t_{10}=8.00, p<0.001), and mental training group (t_9=7.37, p<0.001) before and after educational intervention. But no significant difference was observed between the pre-test and post-test in the control group (t_8=1.22, p=0.25).

Figure 1. The radial error before and after educational intervention in four mental-physical training, mental training, physical training, and control groups

Discussion

This study aimed to examine the effect of mental training, physical training, and combined (mental-physical) training on

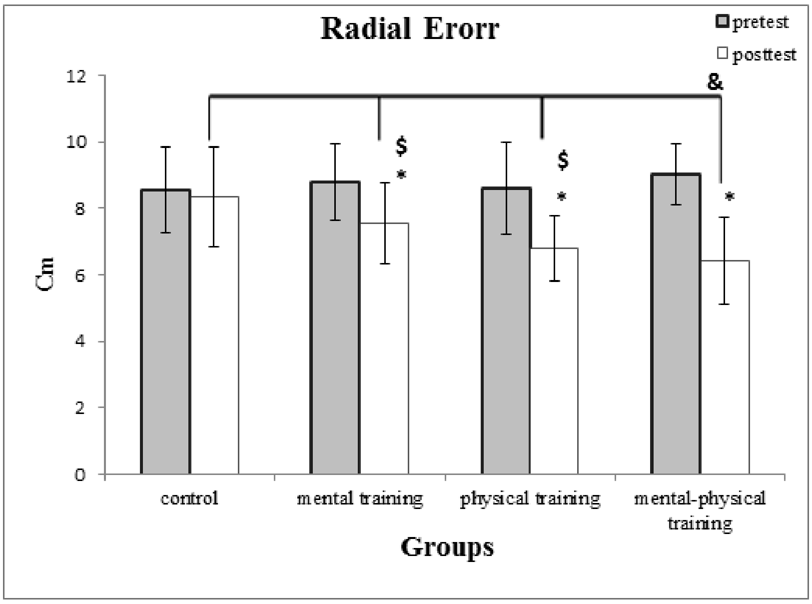

Figure1 *The mean throwing radial error of MS patients in the experimental and control groups before and after educational intervention.*

* Represents a significant difference between the post-test and pre-test (intragroup differences)
& Represents a significant difference between the combined (mental-physical) training group and other groups (the control, mental training, and physical training groups)
$ Represents a significant difference compared with the control group
$p<0.001$ was considered as the significance level.

the targeting accuracy of MS patients. The results showed that all these types of trainings improved the targeting accuracy of the subjects in dart-throwing skill. However, the combined (mental-physical) training group improved the targeting accuracy more compared with other types of trainings.

Physical trainings have proved effective on mobility in patients with neurological deficit. Liepert [25] reported that physical training in patients with chronic neurological deficit increases the nervous flexibility and improves their performance. This study also confirms that the physical training is useful for increasing the motor function of patients with spinal cord injury. Certain training programs have proved effective in improving accuracy.

The results also showed that mental trainings can improve subjects' accuracy. It seems that mental training is effective in improving the performance of MS patients. There are different theories about how mental training affects motor learning and development of motor skills, among which the symbolic learning theory is one of the mechanisms that justify the positive impact of the mental training in this study. According to this theory, Sackett suggested that mental training encodes the movements required for performing the skill in the brain and thus facilitates learning the skill. This theory assumes that mental training causes a motor program to be created in the central nervous system and the response to this program facilitates learning the motor skill [7]. Research evidence has also indicated that mental and physical trainings have similar neural mechanisms in motor control procedures. In mental training, the imagined movements conform to similar physical rules, motor control, and physiological and pathophysiological conditions existing in actual movements in physical training [26]. Reasons to confirm the theory that mental and physical trainings have common neural mechanisms include: the time of rehearsing an activity is similar to the time during which the person actually performs it. The activity of the automatic system during mental training is similar to the physical training and both have the same neural mechanisms. It has also been reported that many brain structures that are involved in motor control, preparation, and motor planning during the physical training, are also activated during the mental training [18]. The results showed no significant difference between the effect of mental training and physical training on the targeting accuracy of MS patients. It also revealed that combined (mental-physical) training was significantly more effective than mental or physical training alone.

Walter and Viali used the term mental blueprint, in the sense that during the physical training of a skill, a mental map of the movements required for performing that skill is formed in the mind which helps reserving and recalling that skill if necessary [27]. Surburg [28] conducted a study on 40 adolescents with mild mental retardation to examine the effect of mental training on the throwing skill and concluded that combined mental and physical training has the greatest impact on learning. Brouziyne and Molinaro [29] also conducted a study on beginner volunteers in golf and concluded that combined mental and physical training will have the greatest impact on improving the skill of shooting a golf ball. Overdorf et al. [30] indicated that combined mental and physical training is more effective than mental or physical training alone in acquisition and retention of motor skills. More efficacy of combined training compared to mental or physical training alone may be due to this fact that in combined training, corrective feedbacks are provided by the mental training that have a preparatory effect on the physical training and increase the efficiency of physical exercises that will be done later and as a result, the learning increases [31]. According to Magill [31], mental training leads to the best result when it is combined with the physical training. Accordingly, the electrical activity occurring during the mental training will be more effective if it is combined with physical training.

The result of this study can also be justified by the psycho-neuromuscular theory. According to this theory, the mental training of movements leads to action potential and contraction and partial activity of the muscles and the motor feedbacks arising from this partial activity are sent to the brain areas and affect their activities. Therefore, the coordination of nervous and muscular systems is strengthened and the motor learning is improved [32]. Danski et al. [18] examined the effect of motor imagery on the walking of patients after stroke and found that their walking improved. Simmons et al. [33] also stated that motor imagery can have a positive effect on motor function of stroke patients. However, 40% of these patients were unable to do imaging and its effect was not the same in all subjects. Mauro Catalan et al. [34] also carried out a study to treat fatigue in MS patients through motor imagery and indicated that the proposed treatment based on the motor imagery can significantly reduce symptoms of fatigue and improve the quality of life and disability to some extent.

Conclusion

Mental training causes a motor program to be created in the central nervous system and the response to this program facilitates learning the motor skill. All types of trainings, including mental training, physical training, and combined (mental-physical) training used in this study improved the targeting accuracy of MS patients. The results of this study confirm this theory stating mental training facilitates motor learning and support the available evidence on the positive effects of mental training on re-teaching the motor skills to patients with neurological lesions. According to the results of this study and lack of significant differences between the mental and physical training in the targeting accuracy of MS patients, these two training methods can be used as an alternative to each other. But, when these two training methods were combined, a greater improvement was observed in the targeting accuracy of the patients. It seemed that more efficacy of combined training may be due to this fact that in combined training, corrective feedbacks are provided by the mental training that have a preparatory effect on the physical training and increase the efficiency of physical activity that will be done later and as a result, the learning increases. Therefore, using combined mental and physical trainings for rehabilitation of MS patients can be more effective in acquisition of motor skills, especially targeting accuracy than each of the mental and physical trainings alone. The result suggested that 8 weeks physical and mental training (3 session per weeks for 15 min each session) leading to improvement in target accurecy performance in young adult men and women with multiple sclerosis and according to this results, Ms Patients who cannot participate in physical activity due to skeletal-muscle injury or physical disability, they can use of mental training instead of physical training for enhancing of target accuracy

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Contribution

Study design and analysis: KM, HF, MT
Data collection: KM, SK,HF, MT
Manuscript preparation: KM, SK

Conflict of Interest

"The authors declare that they have no competing interests."

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