J Int Acad Phys Ther Res 2020; 11(1): 1999~2004
ISSN 2092-8475
www.iaptr.org
https://doi.org/10.20540/JIAPTR.2020.11.1.1999

Effects of Motor Imagery Training and Balance Training on Static Balance: A Quasi-Experimental Study

Background: Although studies on physical motor learning through motor imagery training have been conducted in various fields, studies on its effectiveness are still considered insufficient.
Objective: To investigate the effect of motor imagery training and balance training on static balance of asymptomatic adults in their 20s.
Design: A quasi-experimental study.
Methods: Thirty-six adults in their 20s who passed the tandem stance test were randomized to the motor imagery training group (MIG, n=12), motor imagery with balance training group (MIBG, n=12), and balance training group (BG, n=12). Each group underwent their respective interventions three times a week for four weeks, and changes in static balance were analyzed using multivariate analysis of variance.
Results: Trace length was significantly lower in the MIBG than in the MIG and BG ($P<.05$), and a significant reduction in trace length in the MIBG was observed after the intervention as compared to the baseline ($P<.05$). Furthermore, a significantly lower velocity was observed in the MIBG than in the MIG and BG ($P<.05$), and a significant reduction of velocity in the MIBG was more observed after the intervention compared to the baseline ($P<.05$).
Conclusion: These results suggest that motor imagery training enhance static balance in healthy college students.

Keywords: *Motor imagery training; Balance training; Static balance*

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Received : 01 February 2020
Revised : 28 February 2020
Accepted : 03 March 2020

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INTRODUCTION

Problems with balance cause fear in performing physical activities and limit the activities of daily living.[1] Strategies to improve balance include lateral weight-shift training,[2] balance maintaining training in various ground conditions,[3] left-right symmetry training using visual and auditory feedback,[4] and taping.[5] However, self-training involving rehabilitation exercise and motor imagery training is recommended as a training strategy as it is considered a time- and cost-effective strategy.[6] Motor imagery training refers to a mental process of performing given physical activities without actually performing them, and it is a type of motor learning through which individuals learn and improve their motor skills.[7] The effects of motor imagery training have been supported with neurophysiological evidence. Mary et al[8] reported that motor imagery training is a neurorehabilitative approach based on the theory of neuroplasticity that enhances physical functions and alters motor-related areas of the brain. Motor imagery training is being studied in an array of disciplines, including sports training[9] and rehabilitation training,[10] and balance training, a training for acquiring novel motor skills, has been reported to be highly effective in improving continuous motor skills and learning new motor skills.[11] Although research on physical motor learning through motor imagery training is ongoing in multiple fields, studies on its effects are considered inadequate. Therefore, this study aims to investigate the effect of motor imagery training and balance training on the static balance of asymptomatic adults in their 20s.

SUBJECTS AND METHODS

Subjects

Thirty-six students of N University based on Cheonan, South Chungcheong Province without musculoskeletal, neural, or orthopedic disability that may affect their balance maintenance[12] were enrolled (Table 1). The sample size was calculated using the G*Power software. Based on Cohen's study,[13] we anticipated a large effect size of 0.4. The required sample size was calculated to be 30, and with potential 20% withdrawal rate, we determined that 36 participants were required. Thus, this study had an appropriate sample size. The eligibility of the selected 36 participants in this study was assessed through a screening. Participants who passed the screening were randomized to the motor imagery training group (MIG, n=12), motor imagery with balance training group (MIBG, n=12), and balance training group (BG, n=12). Regarding the participants' group allocation, we prepared 36 sealed envelopes containing a piece of paper showing "A (MIG)", "B (MIBG)", or "C (BG)" (12 each). The participants randomly selected one envelope and turned it in to the operator without checking the paper inside. The operator administered the interventions indicated by the envelope to each participant.[14] Both, the participants and assessors who collected the data were blinded from the group allocation results. All participants thoroughly understood the purpose and content of this study before voluntarily providing a written consent form. This study was approved by the Institutional Review Board of Namseoul University(IRB NSU 202003-002).

Screening

The tandem stance test is an instrument used to assess static balance ability.[15] During this task, individuals must maintain an upright balance on a narrow base of support without taking a step or using assistance. Individuals who cannot maintain this posture for at least 10 seconds are at a higher risk of falls and functional decline. In this study, the tester utilized the standard protocol, where the tester demonstrated a tandem stance position (heel-toe) and instructed the participants to maintain a tandem stance position for at least 10 seconds without taking a step or using support. No practice trials were allowed. The timing of 10 seconds has begun the moment the participants assumed a tandem stance position and were able to stably hold the correct position. The test was stopped when a foot moved out of position or a hand was placed on the support.[16] Participants who were unable to maintain a tandem stance position for 10 seconds were excluded from the study.

Static Balance Measurements

Static balance, the dependent variable of this study, was measured at the baseline before beginning the 4-week intervention and again after completing the 4-week intervention. Static balance was measured using the HUR BT4 balance platform (HUR Labs, Tampere, Finland), based on which, the changes after intervention were examined. The Romberg test was used, where participants took off their shoes, stepped onto the equipment, and spread their heels by 2 cm with their feet pointed at 15° laterally with both hands naturally placed on their pants.[17] The participants were instructed to gaze forward and stand for 30 seconds with minimal sway during the measurement. Trace length (TL), center of pressure, and velocity were measured as the study parameters. Lower values of these parameters indicate improved static balance.[18]

Motor Imagery Training

Motor imagery training was conducted in 30-minute sessions (three times a week for 4 weeks). The interventions were performed in a quiet indoor

Table 1. General characteristics of the subjects.

Variables	MIG (Mean ± SD)	MIBG (Mean ± SD)	BG (Mean ± SD)	*P*
Age (year)	21.58 ± .51	22.08 ± .90	22.00 ± .00	.14
Height (cm)	166.19 ± 3.84	167.64 ± 6.54	172.40 ± 8.32	.25
Weight (kg)	60.90 ± 11.35	70.23 ± 17.49	75.58 ± 13.15	.47
Sex (male/female)	6/6	8/4	8/4	

MIG: Motor imagery training group, MIBG: Motor imagery with balance training group, BG: Balance training group space to help participants focus on the training. With the participants seated on a chair with armrest and backrest comfortably, their eyes were covered with a blindfold.[19] The researcher verbally explained the contents of the balance training program shown in Table 2 for 30 minutes. While listening to the explanation, the participants were instructed to imagine and feel their bodies move and maintain balance,[20] and to confirm that they are actively participating in the process, we asked five questions throughout the training to check their states.

Combined Training

The combined motor imagery training and balance training was conducted in 30-minute sessions (three times a week for 4 weeks). After physically performing a warm-up exercise for 5 minutes, the balance training program shown in Table 2 was performed for 10 minutes with the number of reps cut in half. Subsequently, they comfortably sat on a chair, and their eyes were covered with a blindfold. The researcher explained the existing balance training program with the number of reps reduced by half for 10 minutes, and the participants were instructed to perform motor imagery training. Finally, they physically performed 5 minutes of cool-down exercise.

Balance Training

Balance training was conducted in 30-minute sessions (three times a week for 4 weeks). We modified the Otago exercise program developed by Gardner et al[21] such that the exercise was performed on an unstable base of support. An unstable base of support was provided using a balance Pad (Alusuisse Airex AG, Sins, Switzerland) and air cushion (Dynair Ballkissen, Togu, Germany). The details of the program are shown in Table 2.

Statistical Analyses

All the measured data were processed by the program of IBM SPSS Statistics version 20.0. The normal distribution of all the data was validated by the Kolmogorov-Smirnov (K-S) test, and the general characteristics of the subjects were calculated by descriptive statistics. The main effects and interactions of group and time for dependent variables were analyzed using multivariate analysis of variance (MANOVA), and Bonferroni was used as a post-hoc test. The significance level was set at α=.05.

RESULTS

The main effect of TL was significantly observed ($P<.05$), and post-hoc test showed that the MIBG had significantly smaller postural sway than the MIG and BG. The main effect of time was also significant ($P<.05$). Post-hoc test confirmed that a significant reduction of postural sway in the MIBG was more observed after the intervention compared to the baseline ($P<.05$). However, a group and time interaction effect was not observed ($P>.05$). The main effects of group and time for center of pressure (C90) were not observed ($P>.05$), and a group and time interaction effect was not observed ($P>.05$). A significant main effect of velocity was observed ($P<.05$), and post-hoc test showed that the MIBG had significantly smaller postural sway than the MIG and BG. The main effect of time was also significant ($P<.05$). Post-hoc test confirmed that a significant reduction of postural sway in the MIBG was more observed after the intervention compared to the baseline ($P<.05$). A group and time interaction effect was not observed ($P>.05$) (Table 3).

Table 2. Balance training program.

Order	Type	Duration	Period
Warm-up	stretching	5 min.	4 weeks
Balance training	1. on the balance pad - up on toes: hold for 10 seconds, 10 rep. - back on heels: hold for 10 seconds, 10 rep. - knee bends (squat 45°): 20 rep. 2. on the air cushion - up on toes: hold for 10 seconds, 10 rep. - back on heels: hold for 10 seconds, 10 rep. - knee bends (squat 45°): 20 rep.	20 min. *rest - between rep.: 5 sec. - between type: 1 min.	
Cool-down	stretching	5 min.	

Table 3. Multivariate analysis of variance for static balance.

		Pre (Mean ± SD)	Post (Mean ± SD)		*P*	*post-hoc*
TL (㎟)	MIG	360.91 ± 135.75	295.50 ± 83.06	G	.02*	G1<G2,G3
	MIBG†	267.27 ± 103.12	206.85 ± 64.55	T	.00*	
	BG	334.49 ± 94.54	299.77 ± 72.37	G*T	.84	
C90 (㎟)	MIG	266.61 ± 174.69	303.01 ± 171.31	G	.45	
	MIBG†	249.43 ± 234.37	150.93 ± 80.55	T	.19	
	BG	328.52 ± 337.97	279.29 ± 157.18	G*T	.53	
V (㎜/s)	MIG	11.65 ± 4.63	9.85 ± 2.77	G	.03*	G1<G2,G3
	MIBG†	8.91 ± 3.44	6.90 ± 2.15	T	.00*	
	BG	11.15 ± 3.15	9.99 ± 2.41	G*T	.89	

**P* < .05, †*P* < .05 (Compared of intra-group), TL: Trace length, C90: Center of pressure, V: Velocity,
MIG: Motor imagery training group (G1), MIBG: Motor imagery with balance training group (G2),
BG: Balance training group (G3), G: Group, T: Time, G*T: Group*Time

DISCUSSION

This study aims to investigate the effect of motor imagery training and balance training on the static balance of university students. In this study, we assessed the changes in static balance ability after a 4-week intervention using the HUR BT4 balance platform (HUR Labs, Tampere, Finland). The results showed that the significant main effects of trace length (TL) and velocity were observed in both groups, and post-hoc test confirmed that the motor imagery with balance training group (MIBG) had significantly lower TL and velocity than the motor imagery training group (MIG) and balance training group (BG). Regarding time, a significant reduction in TL and velocity in the MIBG was more observed after the intervention compared to the baseline. These results show that combining motor imagery training is more effective in improving static balance than using balance training alone. Motor imagery entails performing cognitive tasks for the given movement or specific task in imagination without actual physical execution,[22] and using motor imagery, where an action is imagined without physical execution, is one of the feasible interventions for preventing a decline of mobility.[23] In a study that applied motor imagery training with ankle strengthening exercise in stroke patients with hemiplegia, Kim et al[20] reported that the training increased the percentage of weight support in the affected side and that motor imagery training is an effective treatment modality for stroke patients. Nicholson et al[23] administered a single training session of imagery training where adults aged ≥65 years finish an obstacle course while sitting on a chair and repeat it 20 times, followed by a locomotor test. The participants showed a learning process for a complex motor task, with improved timing and locomotor performance during a locomotor task, for that reasons the authors reported that motor imagery training can improve mobility in elderly adults. Grezes and Decety[24] reported that motor imagery elicits activities in the brain regions that are normally activated during actual task performance. The reason behind the influence of motor imagery training on human mobility can be explained based on the reported literatures. In a brain imaging study that compared actual movement and motor imagery training, Gerardin et al[25] found that similar responses are shown in the premotor, parietal lobe, basal ganglia, and cerebellum, and Dunsky et al1 reported that motor imagery training enhances dynamic balance ability by building a nerve network and facilitating proprioceptive sense, kinesthesia, and coordination capability. Furthermore, Loporto et al[26] observed cortical activation in the motor area during motor imagery training in their study utilizing noninvasive brain stimulation techniques, and Sun et al[27] confirmed cortical reorganization after motor imagery in stroke patients in their neuroimaging study. Taken together, motor imagery training seems to improve human body movements by activating the brain similar to that seen in actual physical movement, based on the a observation of result consistent with the result of our present study in which an enhancement of static balance was observed after a motor imagery training intervention. Although we studied the general population, subsequent studies should apply and assess the effects of motor imagery training in participants with various diseases that entail physical limitation, subsequently contributing to clinical interventions.

CONCLUSION

The results of this study show that motor imagery training enhances static balance in healthy college students. These results suggest that exercise program including motor imagery training could be more improve balance.

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