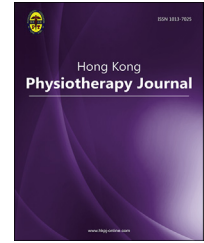




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RESEARCH PAPER

# Effects of the Bad Ragaz Ring Method on muscle activation of the lower limbs and balance ability in chronic stroke: A randomised controlled trial



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## KEYWORDS

Bad Ragaz Ring method;  
balance;  
stroke

**Abstract** *Background:* Recovery of balance and walking abilities is important for the rehabilitation of stroke patients.

*Objectives:* To evaluate the effects of the Bad Ragaz Ring method on functional recovery in chronic stroke patients.

*Methods:* Twenty-two chronic stroke patients were randomly assigned to two groups: a Bad Ragaz Ring method group (the experimental group) or a control group. Stroke patients in the experimental group underwent Bad Ragaz Ring exercise and comprehensive rehabilitation therapy, whereas patients in the control group underwent comprehensive rehabilitation therapy alone. The participants in both groups received therapy 3 days per week for 6 weeks. Muscle activations, balance indices, and Timed Up and Go test results were assessed before and after the 6-week therapy period.

*Results:* The experimental group showed significant improvements in activations of tibialis anterior and gastrocnemius muscles, balance index, and Timed Up and Go test results as compared with preintervention results ( $p < 0.05$ ), whereas the control group showed significant improvement in Timed Up and Go test ( $p < 0.05$ ). Significant differences in posttraining gains in the activations of tibialis anterior and gastrocnemius muscles and in balance index were observed between the experimental and control groups ( $p < 0.05$ ). Effect sizes for gains in the experimental and control groups were strong for tibialis anterior and gastrocnemius muscles (effect sizes, 1.04 and 1.45 respectively).

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**Conclusion:** The Bad Ragaz Ring method may be beneficial for improving balance and leg muscle activation of chronic stroke patients.

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## Introduction

Thanks to the advancements made in medical technologies and increased awareness of stroke, stroke-related death rates continue to decline. However, many stroke patients suffer from physical and mental disabilities, and of these physical disabilities, balance and walking disorders are major concerns [1].

Common balance disorders include postural instability and sway [2], and walking disorders include decreased walking speed [3], hemiplegic gait pattern [4], and reduced weight shift to the affected leg. Balance and walking disorders delay the recovery of mobility and motion, and thus, increase the risk of falls [5]. Therefore, the recoveries of balance and walking abilities are important for the rehabilitation of stroke patients.

Many studies have been conducted to develop therapeutic techniques to minimize the after effects of stroke. Therapy programs depend on patient status and usually include balance training, postural awareness training, strengthening exercise, transfer activities, and gait training [6]. Of these, balance training, postural training, and motor learning intervention, proprioceptive neuromuscular facilitation (PNF), and neurodevelopment treatment (NDT) are most commonly and widely used [7].

Aquatic therapies designed to improve balance and walking abilities, have recently attracted attention, and have been suggested for the rehabilitation of stroke patients. Currently, aquatic therapy is widely used to treat chronic diseases, such as, arthritis, nerve disorders, and cerebral palsy [8], as water provides an excellent medium for healthy individuals and those with disability due to its physical characteristics of viscosity, buoyancy, density, specific gravity, and hydrostatic pressure [9]. Furthermore, when submerged in water, hydrostatic pressure promotes equal resistance to all muscle groups and increase sensory input [10]. In addition, the hydrodynamic elements of water, including metacentric effects and inertia, are essential for the maintenance and restoration of balance [11].

As balance recovery and walking abilities are essential features of the rehabilitation of stroke patients, aquatic therapy is likely to be advantageous, as is being increasingly realized. Various types of aquatic therapy, including the Halliwick Method, the Watsu method, and the Bad Ragaz Ring Method are being used to rehabilitate stroke patients. Noh et al [8] reported that aquatic therapy helped stroke patients control posture and strengthens muscles.

Florian et al [12] found aquatic therapy significantly improved the functional movements of subacute stroke patients. Montagna et al [13] found Halliwick therapy significantly improved quality of life and balance ability in

stroke patients, and Kwon et al [14] confirmed that postural sway reduced and vestibular functions improved in stroke patients that underwent Halliwick therapy underwater.

In the present study, we applied the Bad Ragaz Ring Method to patients with chronic stroke to determine its impacts on lower limb muscle activity and balance ability.

## Materials and methods

### Participants

Patients were recruited from the neurological physical therapy outpatient clinic of the Faculty of Physical Therapy, Eulji University Hospital in Daejeon. Patients ( $n = 50$ ) with stroke were screened for this study from June 2015 to August 2015. The inclusion criteria were: (1) sufficient cognitive ability to follow instructions (Mini-Mental State Examination score  $\geq 24$ ) [15]; (2) mild spasticity in all joints of the affected limb (Modified Ashworth Scale score  $< 3$ ) [16]; (3) no muscular–skeletal disorder or history of lower extremity surgery; (4) a higher than fair score on the Manual Muscle test [17]; (5) the ability to walk  $> 10$  m without any assistive device, such as, a cane or walker; (6) no unilateral neglect, hemianopsia, or apraxia; and (7) no psychological or emotional problem.

The exclusion criteria were as follows: (1) participation in a drug or experimental rehabilitation project within the previous 6 months; (2) serious vision or visual perception impairment (e.g., neglect or poor visual field) [18]; and (3) the presence of a severe neuropsychologic, neuromuscular, or orthopedic disease.

Twenty-two chronic stroke patients met the study criteria. The Research Ethics Committee of Eulji University Hospital approved the study, and all participants provided informed, written consent prior to enrolment. After initial assessments, participants were randomly assigned to an experimental group ( $n = 11$ ) or a control group ( $n = 11$ ).

For randomisation, sealed envelopes were prepared in advance and marked inside with an A or B, indicating the experimental and control groups, respectively. The randomisation was performed by a third party totally unaware of the study content. Participant characteristics and all outcome measures before and after treatment were assessed by a physician, who was blinded to treatment allocations.

The sample size for this study was calculated using the G\* Power program 3.1.0 (G power program Version 3.1, Heinrich-Heine-University Düsseldorf, Düsseldorf, Germany). Based on data from a pilot study, the estimated sample size required to obtain a minimum power of 80% at a significant alpha level of 95% was 18. Accordingly, 22

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