한국전문물리치료학회지 2015년 22권 4호 34-43 ISSN (Print) 1225-8962, ISSN (Online) 2287-982X
Phys Ther Korea 2015;22(4):34-43 http://dx.doi.org/10.12674/ptk.2015.22.4.034

Effects of Underwater Treadmill Gait Training on Gait, Balance, and Pulmonary Function in Stroke Patients

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Abstract

The purpose of this study was to compare the effects of underwater treadmill gait training (UTGT) and overground treadmill gait training (OTGT) on the gait, balance ability and pulmonary function of stroke patients. Twenty subjects were recruited for this study. The subjects were randomly assigned to two groups: UTGT (n_1=10) and OTGT (n_2=10). The 10 m walk test (10 MWT), Berg Balance Scale, Timed Up and Go (TUG) test, center of pressure, pulmonary function of forced vital capacity (FVC), forced expiratory volume after 1 sec (FEV1) and FEV1/FVC were measured before and after 4 weeks of training. Both groups undertook the gait training for 30 min a day, 3 times a week, for 4 weeks, and rating of perceived exertion of the groups were measured and compared. All the studied variables were significantly improved in both groups ($p<.05$) at the end of the study, except in the FEV1 of OTGT ($p>.05$). There was significant between-group difference in all of the variables, except in the 10 MWT ($p>.05$). These findings suggest that UTGT is more effective than OTGT in improving the balance and pulmonary functions of stroke patients.

Key Words: Balance; Gait training; Pulmonary function; Stroke; Underwater treadmill.

Introduction

Stroke causes damage to motor and sensory nerves. Such damage induces functional disorders in stroke patients, including gait disturbances (Williams et al, 1999). Among stroke patients, 75% can walk independently, but 50% of them still have gait disturbances (Hyndman et al, 2002). Reduced muscles activity, difficulty in weight shift, and a decline in balance functions due to degraded proprioceptive senses mainly cause gait disturbances. Compared to healthy individuals, stroke patients show reduced mobility and stability and different gait patterns, resulting in increased energy costs and limited gait endurance (Patterson et al, 2007). In addition, compensated motor patterns, such as circumduction gaits are found in stroke patients (Gillen, 2010; Kim and Eng, 2003; Roth et al, 1997).

Balance is an ability to maintatin the line of gravity of a body withing the base of support with minimal postural sway (Shumway-Cook et al, 1988). For maintaining balance need to visual feedback, vestibular and proprioceptive sense (Pollock et al, 2000). Stroke patients have decrease control mobility, weak muscle power and hemianesthesia that affect balance problems. They have been implicated in the poor recovery of activities of daily living (ADL) and mobility and an increased risk of falls. Thus Stroke patients are necessary to improve balance ability for functional mobility, stability and ADL (Tyson et al, 2006).

Stroke patients may also exhibit breathing disorders, with breathing problems due to the weakening of the diaphragm, the intercostal muscles, and the abdominal muscles (Lanini et al, 2003). Stroke patients with neuromuscular system disease are unable to take deep breaths at regular intervals. The decreased breathing ability reduces physical abilities, functional mobility, and independent gait ability (Kang,

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2003). Independent gait ability is an important element in quality of life and participation in daily living. In rehabilitation treatment, it is one of the most important abilities to improve for a return to daily living (Flansbjer et al, 2005; Lord et al, 2004). According to previous studies, appropriate rehabilitation exercises for pulmonary functions should be included in the rehabilitation treatment of stroke patients.

Overground treadmill gait training (OTGT) is gait training using mechanical assistance, such as a harness or belt. With practice, OTGT improves the timing of the lower extremity during gaits to increase the extension of the hip joint during stance phases. Changes in gait patterns contribute to improvements in the symmetry of gaits (Ada et al, 2003; Harris-Love et al 2001). Providing positive feedback to a patient taking part in OTGT can improve a patient's spirits and motivate the patient to feel more confident about walking (Moore et al, 2010). In addition, OTGT can strengthen the lower extremity muscles and improve gait velocity, gait endurance, and cardiopulmonary functions (Macko et al, 2001; Silver et al, 2000).

Underwater treadmill gait training (UTGT) is similar to OTGT in terms of body support, but it enables gait training with reduced weight using the buoyancy of water (Simmons and Hansen, 1996). Water has various physical characteristics, such as buoyancy, hydrostatic pressure, and viscosity that affect the human body (Becker, 2009). In OTGT, the patient has to wear a harness or belt for weight bearing. This is not necessary in UTGT where the water assists the stroke patient's balance ability. Furthermore, training in water reduces the patient's fear of falling and aids their sense of stability (Jung et al, 2010). A previous study that compared UTGT and OTGT implemented at the same velocity reported that the gait patterns and muscle strength of the UTGT group improved to a greater extent than those of the OTGT group (Park et al, 2012). As recent study investigated the effects of UTGT on the peak torque of the knee in stroke patients, UTGT showed an increase in the peak knee extension torque (Lee et al, 2015). In addition, Aquatic exercise showed that to enhance the balance and decrease the depression of stroke patients (Kim et al, 2014). UTGT in adults with osteoarthritis was more effective than OTGT for improving balance ability (Bressel et al, 2014). Water immersion and UTGT may reduce the workload of the cardiovascular system. The mean maximum increases in blood pressure, heart rate and the rate pressure product of UTGT were significantly lower than that of OTGT (Yoo et al, 2014). In another study, the metabolic costs and the heart rates and rating of perceived exertion (RPE) scores of the UTGT group were higher than those of the UTGT group at the same stride length (Masumoto et al, 2013).

In rehabilitation treatment, underwater exercises are attracting increased attention. However, there are limited studies of UTGT among stroke patients and even fewer studies of the effects of UTGT on stroke patient's balance and pulmonary functions. In addition, earlier studies had used velocity-based indicators which were objective and did not consider subjective issues, such as a patient's psychological stability or the environment. In the our study, we hypothesized that UTGT would be more effective than OTGT in improving the gait, balance, and pulmonary function of stroke patients. To test this hypothesis, we examined differences in the effects of UTGT and OTGT on stroke patients' balance, gaits, and pulmonary functions at the same exercise intensity according to the patients' RPE scores.

Methods

Subjects

The study consisted of 20 stroke patients with gait disturbances and poor respiratory function in D Hospital in Daejeon. All of the protocols used in this study were approved by the University of Daejeon. The participant's rights were protected according to the guidelines of the University of Daejeon (approval