Effectiveness of Constraint-Induced Movement Therapy for Balance

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Contributor: Gopal Nambi

Constraint-induced movement therapy (CIMT) is one of the most popular treatments for enhancing upper and lower extremity motor activities and participation in patients following a stroke. However, the effect of CIMT on balance is unclear and needs further clarification. Recent evidence indicate that CIMT interventions can improve balance-related motor function better than neuro developmental treatment, modified forced-use therapy and conventional physical therapy in patients after a stroke.

constraint-induced movement therapy stroke balance

1. Introduction

The second most common cause of death and disability worldwide was stroke [1], with more than 116 years of healthy life lost worldwide each year due to deaths and disability related to strokes [2]. Many advanced rehabilitation methods to treat patients after a stroke, including robotic-assisted technology [3][4][5], transcranial brain stimulation [2][5][6], virtual reality techniques [7], and game-based rehabilitation [8], have emerged in recent decades. Along with these advanced rehabilitation methods, the traditional approaches of neurodevelopmental treatment [9], proprioceptive neuromuscular facilitation [9][10][11], constraint-induced movement therapy (CIMT) [12], and task-oriented training [13] continue to be popular and used for the rehabilitation of patients after stroke to improve strength, balance, gait, function, and quality of life.

Among the traditional approaches, CIMT was first developed for the upper extremity and consisted of constraining the unaffected upper extremity to improve the function of the paralyzed upper extremity [14][15]. Researchers have since further utilized CIMT for the lower extremity and trunk to improve motor function [16][17][18][19][20]. Despite being designed to improve upper extremity function, many researchers have surprisingly noted improvements in balance as well [21][22][23].

Balance is the ability to use muscular forces to control the center of gravity both within and outside of the base of support [24]. Balance is one of the core determinants of independent gait [25] and quality of life [26] in the stroke population. During CIMT, when the upper extremity, trunk, or lower extremity is constrained, the patient is required to perform specific functional tasks prescribed by the therapist without the aid of the unaffected extremity. The patient thus must move the affected side, causing a shift in the center of gravity on the base of support that indirectly improves the central feedforward mechanisms to the muscular systems controlling the body and enhances balance [22].

There are many methods of objectively measuring balance in patients after stroke. Researchers have measured static, dynamic, and functional mobility components of balance among patient's post-stroke. For example, the static element of balance has been measured by the center of pressure [27], center of mass [28], and symmetrical weight-bearing [29]. The dynamic component of balance has been measured using reach distances [30] and the Berg Balance Scale (BBS) [31], while functional mobility components have been measured by Dynamic Gait Index [31] and Timed Up and Go Test (TUG) [31].

The previous systematic review focused on finding the effects of lower extremity CIMT on balance and functional mobility have provided positive effects in their systematic review; however, a meta-analysis could not show the significant effect size [17] and recommended to conduct a future meta-analysis including more studies.

2. Constraint-Induced Movement Therapy

Previous reviews of CIMT involved many impairment measures, such as range of motion and spasticity, and activity measures, such as gait and upper and lower extremity function, though many did not consider the crucial components of balance and functional mobility [17][32][33][34][35].

The results of the systematic review indicated that the CIMT has either positive effects or equal effects compared to the controlled interventions. There are many factors which may influence these results, such as type of interventions in the control group, type of constraints, duration of immobilization, duration of intervention, and variability in the balance outcome measures. While considering the duration of the interventions, the Zhu et al. [36] study found significant effects of CIMT on center of mass displacements. However, the unequal distribution of duration of intervention favoring the CIMT group might be the reason for the above positive effects. With regard to the intervention, there is variability in the control groups; the majority of them used conventional physical therapy [37][36][38], some studies used neurodevelopmental treatment [21][39], some researchers used modified force use of upper extremity [22], and others used treadmill and overground gait training [23][40]. This variability of the interventions might provide the reasons for inconsistent improvements found in the control groups. Further, this factor would have favored the improvements in the experimental group as whole. As per the core principles of CIMT, behavioral modification, repetitions, transfer package and constraint are important. Two researchers[37][36] used augmentation by shoe inserts and encouragement of weight bearing on the affected side, and others used restraint of unaffected limb [21][22][23][40][36][39], to maximize the participation of the affected limb. However, both restraint and augmentation showed the positive effects on improving the balance of the patients.

Current findings were comparable to the conclusions of the study by Abdullahi et al. [17], which focused exclusively on the effects of lower extremity CIMT on the stroke population, including multiple lower extremity functional components such as gait, lower extremity motor function, balance, functional mobility, and quality of life. Their effect size from the meta-analysis was 0.62 (95% CI [−0.54 to 1.78]) for balance and −0.53 (95% CI [−3.61 to 2.55]) for functional mobility, showing a statistically insignificant effect of lower extremity CIMT on both balance and functional mobility. In current study, the effect size calculated from the meta-analysis of balance was 0.51 (95% CI [0.1–0.91]), which indicated a statistically significant effect of CIMT on balance; however, when researchers examined functional mobility in a meta-analysis, the effect size was −2.73 (95% CI [−8.59 to 3.13]), indicating a statistically insignificant effect of CIMT on functional mobility. Nevertheless, the significant effect size in the meta-analysis on balance supports the positive effects of CIMT on balance, which may be due to the inclusion of studies focusing on upper extremity CIMT. In addition, in Abdullahi et al. [17], three research works were incorporated in the meta-analysis of balance, including the BBS and FRT outcomes. In contrast, seven research works were incorporated in the meta-analysis of balance, and their outcome measures were the BBS, FRT, LOS, and TIS.

The subgroup analysis of the effect of upper extremity CIMT on balance was statistically significant, with an effect size of 0.55 (95% CI [0.18–0.92]) and homogeneity. In contrast, the effect of lower extremity CIMT on balance was statistically insignificant, with the effect size of 0.56 (95% CI [−0.15 to 1.26]) and heterogeneity of I2 = 71%. This may be due to variability in the lower extremity CIMT methodology in terms of the type of constraint, duration of treatment, and type of control group intervention. Moreover, the upper extremity CIMT has a substantial influence on trunk control in practice; the constraint of the normal upper extremity forces the affected upper extremity to move. Without adequate upper extremity control, patients undergoing CIMT might use their trunk to aid in the upper extremity movement, thus leading to a greater shift in the center of gravity on the base of support and better improvement in the balance outcome measures [22][41][42].

Researchers establish an important influence of CIMT on balance but not on functional mobility as measured by the TUG test. The outcome measures assessing balance primarily focus on static and dynamic components of balance, while the TUG test involves not only static and dynamic components but also walking and turning; this might have contributed to the insignificant effect size [43]. In the current literature, there are only a few studies addressing functional mobility; in the future, a larger number of studies involving this outcome measure may change the significance.

The meta-analysis of post-intervention balance scores showed a significant effect size of 0.51 (95% CI [0.12–0.91]). However, the heterogeneity among the included studies was I2 = 55%, indicating variability in the studies in terms of sample size, methodological quality, duration of the stroke, duration of intervention, type of outcome measure and constraint. Moreover, the risk of bias assessment had revealed some additional factors which might have influenced the study results, such as bias in the patient allotment to the groups, assessment, and handling of incomplete data. The subgroup analysis based on the duration of immobilization and chronicity of stroke did not cause any noticeable change in the results of the meta-analysis.

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