Rehabilitation Effort to Improve Upper Extremity Function in Post-Stroke Patients: A Meta-Analysis

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Abstract. The present study examined the effect of rehabilitation upon improving upper extremity function in post-stroke patients. A meta-analysis combined the results reported in the literature concerning this issue. Fourteen citations met our inclusion criteria, of which the overall effect value was 0.33. However, the reported effects varied considerably. Subgroup analysis revealed the following effect values without significant heterogeneity: the effect value of neurodevelopmental treatment (NDT) compared with conventional physical therapy was –0.01; that of conventional physical therapy compared with no treatment was 0.51; that of EMG biofeedback compared with conventional physical therapy was 0.85 and that of EMG biofeedback compared with no treatment was 0.75. Therefore, it was concluded that the effects of NDT and conventional physical therapy are similar, in that conventional physical therapy has a medium effect and EMG biofeedback has a large effect on improving upper extremity function in post-stroke patients.

Key words: Meta-analysis, Hemiplegia, Physical therapy.

INTRODUCTION

The elderly population is rapidly increasing in advanced nations. The number of people over 65 years old accounted for 15.7% and 12.8% of the total populations of Japan and the United States, respectively, in 19951). As the elderly population has increased, so has the frequency of post-stroke patients. In Japan, 1.4 million individuals presented with central vascular disease in 19932) and that number increased to 1.7 million people in 19963). Although rehabilitation for post-stroke patients is becoming important, the choice of strategy remains a matter of dispute4–9).

Meta-analysis integrates the results of related studies10) and several reports have described the effect of post-stroke rehabilitation effort using this new statistical approach11–13). Ottenbacher and Sylvie reported that the effect value of rehabilitation effort on post-stroke patients is 0.4014). Glanz and colleagues reported the mean effect size of FES as 0.6315) and Schleenbaker and Mainous suggested that the value of EMG biofeedback (EMGBF) is 0.8116).

Functional improvement of the upper extremities is considered to be more difficult than that of the lower extremities in post-stroke patients. Fifty-five percent of the affected upper extremities become totally useless17), although Jorgensen et al. reported that 95% of post-stroke patients could walk18). Meta-analysis of the effect of rehabilitation on each limb also showed that such effort on the lower extremities is significant19), whereas that on the upper extremities is not20). The present study uses meta-analysis to examine the effect of rehabilitation effort upon improving upper extremity function in
post-stroke patients.

METHODS

Clinical studies in the English literature were searched based on exercise of the upper extremities among post-stroke patients between 1966 and 1999 using the MEDLINE database. Inclusion criteria were as follows: (1) cerebral vascular accident that resulted in hemiplegia; (2) independent variables included exercise regimens on the upper extremities; (3) randomized controlled trial design and (4) a measured functional outcome that focused specifically on the upper extremities.

The titles and abstracts were reviewed, and all articles of likely relevance were retrieved and examined. Characteristics of the documented research were then carefully coded.

Effect size $d$, which represented the degree of effectiveness of the independent variable, was calculated from outcome measures in the literature. Disability measures focusing on the upper extremities were given priority as candidates of outcome measures used to estimate effect size. Therefore, the most popular disability measures of the upper extremities, namely the Action Research Arm Test (ARA) and the Fugl-Meyer Assessment Scale (FMA), were used to estimate effect size when those measures were cited. When those measures were not cited, other disability measures of the upper extremities, such as the Rivermead Motor Assessment Arm Scale (RMA), were applied. If a study did not report those measures, then others such as impairment measures, were used. Thus, effect sizes estimated from multiple outcome measures cited in the literature were combined to generate mean effect sizes.

The effect size $d$ was estimated based on the mean, standard deviation and the number of patients described. If the literature measured outcome at several periods, the outcomes measured at post-intervention were preferentially used. If the literature lacked those variables, effect sizes were calculated as follows: $F$, $t$ or $P$ value was alternatively used, or the absent variables were estimated from the presented figures or were requested immediately from the authors. The test of homogeneity assessed whether or not the effect size represented a similar measure of treatment effectiveness.

The software, Meta-Analysis Calculator, based on Hunter, Schmidt, and Jackson$^{20}$ and Hunter and Schmidt$^{21}$ developed by Lyons$^a$ was used to calculate the effect size $d$.

RESULTS

1) Coding characteristics

Fourteen articles$^{22–35}$ including a total sample of 937 patients met the inclusion criteria. Characteristics of the literature are summarized in Table 1. The treatment period varied from 0 to 50 weeks and the post-stroke periods of the patients included in these studies also varied.

2) Effect size in the published literature

The published effect size of the effect of therapeutic intervention on the upper extremities of post-stroke patients was 0.33. However, the test of homogeneity showed significant variation in the research domain ($\chi^2 (13) = 65, P < 0.01$), which indicated that the effect sizes of the 14 reports were not homogeneous.

3) Subgroup analysis

It was assumed that the regimen of therapeutic exercise is the moderator variable. Therefore, 8 out of 14 reports were assigned to four subgroups based on therapeutic regimens as follows: Neurodevelopmental treatment (NDT) compared with conventional physical therapy (NDT subgroup); conventional physical therapy compared with no treatment (conventional physical therapy subgroup); EMGBF compared with conventional physical therapy (EMGBF-NT subgroup); and EMGBF compared with no treatment (EMGBF-C subgroup). Neurodevelopmental treatment is a therapeutic method developed by Bobath$^4$. The present study considers the British, Johnston and Bobath methods as NDT strategies. These four subgroups were further compared using subgroup analysis.

A total of eight reports (two reports each) describing 382, 90, 67 and 62 patients were categorized as belonging to the NDT, conventional physical therapy, EMGBF-C and EMGBF-NT subgroups, respectively.

The estimated effect of the size of the subgroups was: $-0.01$, $0.51$, $0.85$ and $0.75$ in the NDT,

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conventional physical therapy, EMGBF-C and EMGBF-NT subgroups, respectively. The tests of homogeneity for each subgroup did not show significant heterogeneity in the effect sizes.

**DISCUSSION**

Fourteen reports contained randomized controlled trials and investigated the effect of exercise on the upper extremities of post-stroke patients. However, the estimated individual effect sizes described in these reports were not homogeneous. Therefore, the effect of rehabilitation effort upon the upper extremities of post-stroke patients could not be determined from the integrated total of these individual effect sizes.

These papers were subsequently assigned to four subgroups, and the effect sizes of each was estimated. According to Cohen’s criteria, an effect size of 0.8 is large, that of 0.5 is medium and 0.2 is considered to be small. Therefore, an effect size value of –0.01 derived from the literature belonging to the NDT subgroup indicated that the effect of NDT is similar to that of conventional physical therapy. This finding differed from the effect size of NDT applied to children with cerebral palsy reported by Ottenbacher et al.

The effect size value of 0.51 derived from the publications in the conventional physical therapy subgroup indicated that this type of rehabilitation had a medium effect, which in turn, suggested that conventional post-stroke rehabilitation effort is meaningful. This may mean that conventional rehabilitation effort is effective although the effort appears to be less effective in terms of functional improvement and disability level when compared with the results for the lower extremities.

Effect sizes derived from the literatures in the EMGBF-C and EMGBF-NT subgroup were large. This result was similar to that of Schleenbaker and Mainous, who reported an effect size of 0.81. This indicates that EMGBF can help to restore arm function in post-stroke patients.

Among the subgroups of other regimens, the effect sizes of the task-related training described by Dean and Shepherd, the perceptual training report described by Yekutiel and Gutman, and the forced use of the affected arm described by van der Lee et al. were large. These results suggest that these regimens can help improve the condition of upper extremities in post-stroke patients and that further research into these therapies is necessary.

The present study is limited by the small number of reports collated concerning the effect of rehabilitation effort on the upper extremities of post-stroke patients. Only two publications each met the inclusion criteria for each subgroup. However, the sample sizes within each subgroup were sufficiently large for meaningful analysis.

**CONCLUSION**

The present study attempted to investigate the effect of rehabilitation effort on the upper extremities of post-stroke patients. The overall effect size of rehabilitation effort on the upper
extremities of post-stroke patients was 0.33. The effect size of NDT compared with conventional physical therapy was –0.01, that of conventional physical therapy compared with no treatment was 0.51, that of EMG biofeedback compared with no treatment was 0.85 and that compared with conventional physical therapy was 0.75. Therefore, the effects of NDT and conventional physical therapy are almost identical, conventional physical therapy has a medium effect, and EMGBF has a large effect on post-stroke patients.

REFERENCES


