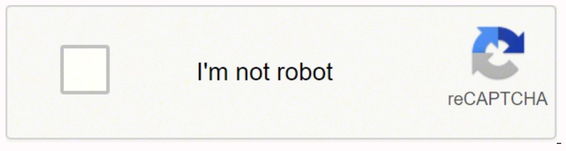

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There were no significant differences between the groups with respect to demographics, medical comorbidities, stroke characteristics, and baseline upper extremity Fugl-Meyer and self-care FIM scores. The study suggests that active repetitive exercises induced by neuromuscular stimulation enhance the motor recovery of acute stroke survivors. All subjects received standard physical, occupational, and speech therapy interventions as per routine of the inpatient stroke rehabilitation program. To make definitive recommendations, a large, multicenter, randomized clinical trial with intervention-specific objective measures of motor and functional impairment should be carried out. However, the gains in the motor function did not translate into significant improvement in the performance of basic self-care activities. The restoration of motor function following hemiplegia in man. Phys Ther.1983; 63:1096–1103.CrossrefMedlineGoogle Scholar31 Kraft GH, Fitts SS, Hammond MC. 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Gains in the Upper-Extremity Fugl-Meyer and Self-care FIM Scores After Treatment and at Follow-up PeriodsNeuromuscular Stimulation (SD)Control (SD)Difference (SE)95% Confidence Interval1414Fugl-Meyer gain1After treatment13.1 (10.3)6.5 (6.1)6.6 (3.2)13.2, 0.14 weeks17.8 (12.6)9.7 (7.7)8.1 (3.9)16.2, 0.012 weeks20.6 (15.1)11.2 (8.7)9.4 (4.7)18.9, −0.2FIM gain2After treatment11.3 (3.0)10.6 (5.9)0.6 (1.8)4.3, −3.04 weeks13.9 (5.5)13.6 (6.5)0.3 (2.3)5.0, −4.412 weeks15.8 (5.8)16.1 (6.7)−0.3 (2.4)4.6, −5.1This study was supported in part by the Rehabilitation Medicine Scientist Development Program (NIH 1K12 HD01097–01A1) and the Physical Medicine and Rehabilitation Education and Research Foundation (New Investigator Award).Footnotes References 1 Indredavik B, Bakke F, Solberg R, Rokseth R, Haaheim L, Holme I. Arch Phys Med Rehabil.1997; 78:615–620.CrossrefMedlineGoogle Scholar48 Wade D. The gain in the upper extremity Fugl-Meyer and self-care FIM scores are shown in Table 4. Md Med J.1965; 14:61–65.Google Scholar41 Granger C, Hamilton B. Scand J Rehabil Med.1978; 10:147–154.MedlineGoogle Scholar28 Baker L, Yeh C, Wilson D, Waters R. Future studies should use alternative techniques such as percutaneous stimulation to minimize the discomfort of stimulation and the potential confounding effect of selective dropout. Philadelphia, Pa: Harper and Row; 1970.Google Scholar12 Stern P, McDowell F, Miller J, Robinson M. The treatment group received stimulation of the extensor digitorum communis and the extensor carpi radialis (ECR) through circular 2.5-cm surface electrodes. Phys Ther.1983; 63:1606–1610.CrossrefMedlineGoogle Scholar39 Berglund D, Fugl-Meyer A. The small sample size in this study and the high dropout rate after randomization further limit the generalization of the results to the broader stroke population. Stroke rehabilitation: three exercise therapy approaches. Arch Phys Med Rehabil.1993; 74:531–536.CrossrefMedlineGoogle Scholar43 Linacre J, Heinemann A, Wright B, Granger C, Hamilton B. Functional electrostimulation in poststroke rehabilitation: a meta-analysis of the randomized controlled trials. Outcomes were assessed in a blinded manner with the upper extremity component of the Fugl-Meyer Motor Assessment and the self-care component of the Functional Independence Measure at pretreatment, after treatment, and at 4 and 12 weeks after treatment.Results—The treatment subjects and control subjects had comparable baseline characteristics. The assessing therapist was unaware of the treatment assignments. As will be discussed below, the upper extremity–related disability measure used in this study may have been inadequate, and future studies should use measures more specific and sensitive to the intervention.Given these limitations, conclusions must be drawn with caution. Table 1. The reliability and validity of the FIM have been previously documented.41424344AnalysisA sample size of 14 subjects per group was calculated by power analysis with anticipated difference in Fugl-Meyer scores between groups of 1 standard deviation in Fugl-Meyer scores with β of 0.2 and one-tailed α of 0.05. Arch Phys Med Rehabil.1992; 73:220–227.MedlineGoogle Scholar32 Dimitrijevic M, Soroker N. All subjects were still alive at an average follow-up period of 17 months after treatment. The motor recovery enhancing effect of amphetamine in a rat model after unilateral ablation of the motor cortex is blocked if the animals are not allowed to actively and repetitively use their paretic limb.17 A recent study in primates suggests that after local damage to the motor cortex, active repetitive training of the hemiparetic limb shapes subsequent functional reorganization in the adjacent intact cortex and that the undamaged motor cortex plays an important role in motor recovery.1819 A clinical study of subacute stroke survivors also emphasizes the importance of frequent active movement repetition for motor rehabilitation of the centrally paretic hand and challenges conventional physiotherapeutic strategies that focus on tone modification and functional compensation instead of early initiation of active movements.20 Among stroke survivors who are beyond 6 months from their stroke, “forced” active repetitive movement of the paretic limb also appears to enhance motor and functional recovery.2122This study failed to demonstrate that neuromuscular stimulation enhances the upper extremity–related functional recovery of acute stroke survivors. The current amplitude and stimulus frequency were adjusted to subject comfort. When enrolled subjects were dropped from the study, the next subject who qualified for the study assumed the assignment of the dropped subject on enrollment. Functional Independence Measure scores were not different between groups at any of the time periods (P>0.10).Conclusions—Data suggest that neuromuscular stimulation enhances the upper extremity motor recovery of acute stroke survivors. Abstract.Google Scholar26 Levin MF, Hui-Chan CWY. Relief of hemiparetic spasticity by TENS is associated with improvement in reflex and voluntary motor function. Focused stroke rehabilitation programs do not improve outcome. Reorganization of movement representations in primary motor cortex following focal ischemic infarcts in adult squirrel monkeys. Stroke.1992; 23:1084–1089.CrossrefMedlineGoogle Scholar6 Jorgensen H, Nakayama H, Raaschou H, Vive-Larsen J, Stoier M, Olsen T. In contrast to prior studies, this study documents the effects of neuromuscular stimulation on the complex aspect of neurofunctional recovery as reflected by the Fugl-Meyer Motor Assessment and the FIM, and the outcomes are assessed for up to 3 months after treatment.The study has several limitations. J Neurol Sci.1995; 130:59–68.CrossrefMedlineGoogle Scholar21 Wolf S, Lecraw D, Barton L, Jann B. The post-stroke hemiplegic patient: a method for evaluation of physical performance. Tests of arm function474849 that specifically assess the functional ability of the hemiparetic limb and more complex bimanual functional tasks may be more appropriate disability outcome measures for these types of studies.This study suggests that surface neuromuscular stimulation enhances the upper-extremity motor recovery of acute stroke survivors and that the affect is maintained for up to 3 months after completion of treatment. Scan J Rehabil.1975; 7:13–31.Google Scholar37 Brunnstrom S. Electrical treatment of spasticity. However, the sample size in this study was too small to detect any significant effect of neuromuscular stimulation on self-care function.Dedicated stroke units, which admit patients for acute medical management and subsequent interdisciplinary rehabilitation, enhance the overall medical, neurologic, and functional outcome of stroke survivors.12 However, a robust relation between specific treatments directed at motor impairment and corresponding reduction in physical disability has not been established.3 The degree of motor recovery after stroke varies widely and is directly related to the degree of initial severity and the interval from stroke to initiation of voluntary movement.456 During this period, motor recovery is believed to be enhanced by various techniques such as the neurodevelopmental technique,7 sensorimotor integration,8 proprioceptive neuromuscular facilitation,9 biofeedback,10 and functional utilization of evolving synergies.11 However, controlled studies have failed to demonstrate that any one method is superior to the others in enhancing motor or functional recovery of stroke survivors.1213141516Both basic and clinical studies suggest that poststroke motor recovery or motor relearning of the paretic limb may be maximized by the active repetitive use of the affected limb.171819202122 However, many acute stroke survivors exhibit a significant degree of hemiparesis, which limits the application of this strategy in the acute stroke rehabilitation environment. The influence of stroke unit rehabilitation on functional recovery from stroke. Subjects were excluded if they had a history of potentially fatal cardiac arrhythmias, demand cardiac pacemaker placement, seizures within the 2 years before admission, active reflex sympathetic dystrophy, prior stroke with residual motor weakness, lower motor neuron lesion of the impaired upper extremity, spinal cord injury, traumatic brain injury, multiple sclerosis, or Parkinson’s disease. Stroke treatment: comparison of integrated behavioral physical therapy vs. This is consistent with the evolving basic and clinical data on central motor neuroplasticity that support the use of active repetitive training of the paretic limb to maximize motor recovery after stroke. We test an additional hypothesis that the therapeutic effects of the neuromuscular stimulation are sustained for up to 3 months beyond the termination of treatments.Subjects and MethodsSubjectsStroke survivors admitted to an acute inpatient rehabilitation service within 4 weeks of their unilateral stroke were screened for inclusion. Arch Phys Med Rehabil. Modification of motor control of wrist extension by mesh-glove electrical afferent stimulation in stroke patients. Measurement of motor recovery after stroke: outcome assessment and sample size requirements. Baseline Characteristics of Control and Neuromuscular Stimulation GroupsVariableControlNeuromuscular StimulationPn1414Age (SD)60.0 years (15.1)59.4 years (11.1)0.91Stroke onset to treatment (SD)17.8 days (5.9)13.6 days (7.1)0.10Female (%)8 (57.1)7 (50.0)0.71Coronary artery disease (%)5 (35.7)2 (14.3)0.19Congestive heart failure (%)1 (7.1)2 (14.3)0.54Hypertension (%)9 (64.3)10 (71.4)0.69Diabetes mellitus (%)3 (21.4)6 (42.9)0.23History of smoking (%)4 (28.6)6 (42.9)0.43First stroke (%)11 (78.6)10 (71.4)0.66Sensory impairment (%)6 (42.9)5 (35.7)0.69Hemineglect (%)5 (35.7)3 (21.4)0.47Right hemiparesis (%)8 (57.1)5 (35.7)0.33Nonhemorrhagic stroke (%)14 (100)11 (78.6)0.07Cortical stroke (%)9 (64.3)5 (35.7)0.13Anterior circulation stroke (%)11 (78.6)9 (64.3)0.40Upper-extremity Fugl-Meyer (SD)8.3 (8.8)11.1 (10.4)0.45Self-care FIM (SD)19.3 (5.5)21.4 (6.5)0.36 Table 4. Forced use of hemiplegic upper extremities to reverse the effect of learned nonuse among chronic stroke and head injured patients. Eighteen subjects were excluded from the study after randomization for the various reasons shown in Table 1. Techniques to improve function of the arm and hand in chronic hemiplegia. Observations on adult hemiplegia and suggestions for treatment. However, the study failed to demonstrate any significant functional benefit. The analyses of the Fugl-Meyer gain scores with the independent t test revealed significantly greater motor improvement for the NS group before treatment (t=−2.1; P=0.05), at 4 weeks after treatment (t=−2.2; P=0.05), and at 12 weeks after treatment (t=−2.0; P=0.06). More conservative estimates of the effect size with the larger standard deviation of the two treatment groups for each period were 0.64, 0.64, and 0.62, respectively. Future studies should use a functional outcome measure that is specific to the arm and is more sensitive to the degree of arm hemiparesis. There was a high dropout rate, with pain from stimulation being the most common cause. Future studies should also define the dose effect and elucidate the mechanism of action to further guide the clinical implementation of neuromuscular stimulation. Attempts to assess the degree of motor recovery for each group by telephone interview was unsuccessful because family and subjects often reported the degree of paresis to be significantly worse than the previously recorded baseline Fugl-Meyer scores. Approaches to facilitating movement control. In general, subjects in both groups experienced motor recovery in the untreated arm muscles (shoulder abduction-adduction, shoulder external-internal rotation, and elbow flexion-extension) before recovery in the treated forearm muscles (wrist and finger extension-flexion). Functional evaluation: the Barthel Index. In press.Google Scholar46 Chae JC, Johnston MV, Kim H, Zorowitz RD. The difference in the FIM gains scores between groups were not statistically significant at any of the follow-up periods (P>0.10).DiscussionThe major finding of this double-blind, placebo-controlled, randomized study is that stroke survivors treated with surface neuromuscular stimulation gained significantly greater upper extremity motor recovery than did control subjects. Top Stroke Rehabil.1997; 3:5–6.Google Scholar24 Alfieri V. All treatments were carried out under the supervision of a trained occupational therapist. EMG triggered neuromuscular stimulation for improving the arm function of acute stroke survivors: a randomized pilot study. Science.1996; 272:1791–1794.CrossrefMedlineGoogle Scholar20 Butefisch C, Hummelsheim, Denzler P, Mauritz K. Phys Ther.1979; 59:1495–1499.CrossrefMedlineGoogle Scholar29 Bowman BR, Baker LL, Waters RL. While the definitive study remains to be carried out, the evidence from the present study, prior small studies,25262728293031323334 and the recent meta-analysis35 suggest that neuromuscular stimulation may be beneficial for a select group of stroke survivors in maximizing their motor recovery.Presented in part at the 1997 Annual Assembly of the American Academy of Physical Medicine and Rehabilitation. Twenty-eight subjects completed the treatment protocol. Of the 18 subjects who were excluded, follow-up data were available for 17 subjects. Scan J Rehab Med.1982; 14:177–182.MedlineGoogle Scholar25 Levin MF, Chan CWY. The self-care component of the FIM measures general disability and is not arm disability specific. Arch Phys Med Rehabil.1993; 74:347–354.MedlineGoogle Scholar23 Wolf S. Electroencephalogr Clin Neurophysiol.1992; 85:131–142.CrossrefMedlineGoogle Scholar27 Merletti R, Zelaschi F, Latella D, Galli M, Angeli S, Sessa MB. 1990;21(suppl II):II-46-II-47.Google Scholar42 Dodds T, Martin D, Stolov W, Deyo R. Relationship between impairment and physical disability as measured by the Functional Independence Measure. Arch Phys Med Rehabil.1982; 63:613–616.MedlineGoogle Scholar11 Brunnstrom S. The effect sizes at each follow-up period were 0.73, 0.73, and 0.73, respectively. AbstractBackground and Purpose—The purpose of this study was to assess the efficacy of neuromuscular stimulation in enhancing the upper extremity motor and functional recovery of acute stroke survivors.Methods—Forty-six stroke survivors admitted to an inpatient rehabilitation unit were randomly assigned to receive either neuromuscular stimulation or placebo. The treatment group received surface neuromuscular stimulation to produce wrist and finger extension exercises. The stimulation current intensity was set to produce full wrist and finger extension with a duty cycle of 10 seconds on and 10 seconds off. Parametric analyses revealed significantly greater gains in Fugl-Meyer scores for the treatment group after treatment (13.1 versus 6.5; P=0.05), at 4 weeks after treatment (17.9 versus 9.7; P=0.05), and at 12 weeks after treatment (20.6 versus 11.2; P=0.06). J Neurol Neurosurg Psychiatry.1985; 48:7–13.CrossrefMedlineGoogle Scholar Amphetamine, haloperidol and experience interact to affect rate of recovery after motor cortex injury. An intention-to-treat analysis should be used to further minimize the effect of dropout. Neuromuscular reeducation versus traditional programs for stroke rehabilitation. Arch Phys Med Rehabil.1995; 76:406–412.CrossrefMedlineGoogle Scholar7 Bobath B. Arch Phys Med Rehabil.1979; 60:497–502.MedlineGoogle Scholar30 Winchester P, Montgomery J, Bowman B, Hislop H. New York, NY: Harper and Row Publishers Inc; 1968.Google Scholar10 Basmajian JV, Gowland C, Brandstater ME, Swanson L, Trotter J. Measuring arm impairment and disability after stroke. Subjects were assigned to the treatment or placebo group by a computer-generated random number table. The groups were comparable with respect to demographics, medical comorbidities, stroke characteristics, and baseline upper extremity Fugl-Meyer and self-care FIM scores.The baseline characteristics of the NS and placebo subjects are shown in Table 3. traditional physical therapy program. Baseline Characteristics of Subjects Who Dropped Out of the Study After Randomization and Those Who Completed the Treatment ProtocolVariableExcludedCompleted TreatmentPn1828Age (SD)62.2 years (9.4)59.7 years (13.0)0.48Stroke onset to treatment (SD)14.6 days (7.5)15.7 days (6.5)0.61Female (%)10 (55.6)15 (53.6)0.90Coronary artery disease (%)7 (38.9)6 (21.4)0.20Congestive heart failure (%)3 (16.7)3 (10.7)0.57Hypertension (%)16 (88.9)19 (67.9)0.10Diabetes mellitus (%)9 (50.5)9 (32.1)0.23History of smoking (%)6 (33.3)10 (35.7)0.87First stroke (%)13 (72.2)21 (75.0)0.83Sensory impairment (%)9 (52.9)11 (42.3)0.49Hemineglect (%)5 (29.4)8 (28.6)0.99Right hemiparesis (%)7 (38.9)13 (46.4)0.54Nonhemorrhagic stroke (%)15 (83.3)25 (89.2)0.56Cortical stroke (%)10 (55.6)14 (50.0)0.71Anterior circulation stroke (%)12 (66.7)20 (71.4)0.73Upper extremity Fugl-Meyer (SD)9.3 (9.9)9.7 (9.6)0.89Self-care FIM (SD)17.4 (5.4)20.4 (6.0)0.10 Table 3. Twenty-eight subjects completed the study. The FIM, which was historically derived from the Barthel Index,40 is primarily an ordinal scale with some interval characteristics. Am J Phys Med Rehabil.1995; 74:218–223.CrossrefMedlineGoogle Scholar47 Kopp B, Kunkel A, Flor H, Platz T, Rose U, Mauritz K-H, Gresser K, McCulloch K, Taub E. Phys Ther.1996; 66:1233–1238.Google Scholar14 Lord J, Hall K. Subjects were instructed not to discuss the nature of their treatment with the treating and assessing therapists.Motor function was assessed with the upper extremity motor subscore of the Fugl-Meyer Motor Assessment.36 The items in the motor subsections were derived from Brunnstrom’s stages of poststroke motor recovery, although the specific stages were not used.37 Reliability and validity of the Fugl-Meyer Motor Assessment have been documented.3839 The upper extremity–related disability was assessed with the self-care component of the FIM. Previous studies have demonstrated that motor and functional recovery roughly parallel one other.56 Although the lower extremity motor status of stroke survivors correlates well with ambulatory function, the relation between upper extremity Fugl-Meyer and the self-care component of the FIM is modest at best.46 This is due to the nature of the FIM. Admission motor impairment as a predictor of physical disability after stroke rehabilitation. The stimulus pulse was a symmetric biphasic waveform with amplitude ranging between 0 to 60 mA, pulse width of 300 μsec, frequency ranging between 25 to 50 Hz, and ramp up and down time of 2 seconds each. The brevis and longus heads of the ECR could not be further differentiated with surface stimulation. Although the differences in these variables were not statistically significant, the small sample size places the study at risk for a type II error, allowing for the possibility that the treatment group was composed of individuals with greater potential for spontaneous recovery compared with that of control subjects. Physiotherapy.1959; 45:279–289.MedlineGoogle Scholar8 Flanagan E. Science.1982; 217:855–856.CrossrefMedlineGoogle Scholar18 Nudo R, Milliken G. Positional feedback and electrical stimulation: an automated treatment for the hemiplegic wrist. The control group received placebo stimulation over the paretic forearm. Brain.1951; 74:443–480.CrossrefMedlineGoogle Scholar5 Duncan P, Goldstein L, Matchar D, Divine G, Feussner J. Soc Neurosci..1989; 15:916. Stroke survivors with severe upper extremity hemiplegia can score high on the self-care component of the FIM as long as they are able to learn compensatory single-handed techniques to perform the activity. J Neurophys.1996; 75:2144–2149.CrossrefMedlineGoogle Scholar19 Nudo R, Wise B, Sifuentes F, Milliken N. Movement Therapy in Hemiplegia: A Neurophysiological Approach. The functional recovery of stroke: a comparison between neuro-developmental treatment and the Brunnstrom method. EMG feedback treatment of upper limb in hemiplegic stroke patients: a pilot study. The control subjects also received surface stimulation, but the electrodes were placed away from all motor points, producing only cutaneous stimulation just beyond sensory threshold and without motor activation. The arm motor ability test: reliability, validity, and sensitivity to change of an instrument for assessing disabilities in activities of daily living. Effects of feedback stimulation training and cyclical electrical stimulation on knee extension in hemiparetic patients. Among those who completed the treatment protocol, 14 were assigned to the neuromuscular stimulation (NS) group and 14 to the control group. Stroke.1994; 25:821–825.CrossrefMedlineGoogle Scholar3 Dobkin B. The motor function of control subjects was somewhat lower than that of the treatment group. Eighty percent (8 of 10) and 100% (7 of 7) of subjects assigned to the treatment and placebo groups, respectively, were back in the community at follow-up (χ2=1.6; P=0.21). Scan J Rehabil Med.1986; 18:155–157.MedlineGoogle Scholar40 Mahoney F, Barthel D. Electrical stimulation of wrist and fingers for hemiplegic patients. Arch Phys Med Rehabil.1970; 51:526–531.MedlineGoogle Scholar13 Dickstein R, Hocherman S, Pillar T, Shaham R. Arch Phys Med Rehabil.1987; 68:267–272.MedlineGoogle Scholar16 Wagenaar R, Meijer O, Wieringern P, Kuik D, Hazenberg G, Lindeboom J, Wichers F, Rijswijk H. Subjects were 18 years old or older with moderate to severe upper extremity paresis (Fugl-Meyer score less than 44). Arch Phys Med Rehabil.1993; 74:566–573.CrossrefMedlineGoogle Scholar45 Francisco G, Chae J, Chawla H, Kirshblum S, Zorowitz R, Lewis G, Pang S. Arch Phys Med Rehabil.1996; 77:549–553.CrossrefMedlineGoogle Scholar36 Fugl-Meyer A, Jaasko L, Leyman I, Olsson S, Steglind S. Technique to improve chronic motor deficit after stroke. The gain in Fugl-Meyer and FIM scores were compared across groups at each test period with the independent t test.ResultsA total of 46 subjects initially enrolled in the study. The baseline characteristics of subjects who completed the treatment protocol and those who were excluded from the study after randomization are shown in Table 2. A validation of the Functional Independence Measure and its performance among rehabilitation inpatients. Furthermore, the effect appears to be sustained for up to 3 months after completion of treatment. Reliability of the Fugl-Meyer assessment of sensorimotor recovery following cerebrovascular accident. Measurement of stroke rehabilitation outcome in the 1980s. Effects of facilitation exercise techniques in stroke rehabilitation. All subjects were treated 1 hour per day, for a total of 15 sessions. 2nd ed. Repetitive training of isolated movements improves the outcome of motor rehabilitation of the centrally paretic hand. Arch Neurol.1989; 46:701–702.CrossrefMedlineGoogle Scholar4 Twitchell T. The anticipated difference between groups was based on results of a pilot study on the effects of electromyogram-triggered neuromuscular stimulation on the upper extremity motor recovery of acute stroke survivors.45 The baseline characteristics of subjects who successfully completed the treatment protocol and those who dropped out after randomization were compared to assess for potential bias caused by dropout. Numerous studies have suggested that neuromuscular stimulation reduces spasticity242526 and enhances the muscle strength of the hemiparetic limb.262728293031323334 A recent meta-analysis of four randomized trials concluded that neuromuscular stimulation improves the motor strength of stroke survivors.35 The authors write “Given the large burden of disability from cerebrovascular disease and the paucity of efficacious therapeutic modalities, further research on the use of electrostimulation would appear to be prudent (p 552).” In view of the limitations of prior studies, Glanz and associates further recommend that “Future studies should be double-blinded and sham-controlled, and ideally should examine more sustained and complex aspects of neurofunctional recovery after stroke (p 552).” Thus this study uses a double-blind, placebo-controlled, randomized design to test the hypotheses that neuromuscular stimulation enhances the upper extremity motor and functional recovery of acute stroke survivors as reflected by the Fugl-Meyer Motor Assessment and the Functional Independence Measure (FIM), respectively. Subjects Excluded After Randomization, Treatment Assignments, and Reasons for ExclusionReasons for Postrandomization ExclusionNeuromuscular StimulationControlPain or discomfort from surface stimulation71Medical instabilityPulmonary embolism and myocardial infarction01New-onset seizure01Chest pain10Did not finish treatment protocol and declined further treatment32Factitious hemiparesis01Unable to stimulate without motor activation01Total117 Table 2. Arch Phys Med Rehabil.1996; 77:252–258.CrossrefMedlineGoogle Scholar35 Glanz M, Klawansky S, Stason W, Berkey C, Chalmers T. The treatment procedures were in accordance with institutional guidelines. Proprioceptive Neuromuscular Facilitation: Patterns and Techniques. Similarly, the baseline characteristics of treatment and control subjects were compared to assess the success of randomization. The items in the self-care component of the FIM are basic in nature and patients are not penalized for using a single-handed versus a bimanual strategy. The structure and stability of the Functional Independence Measure. Upper extremity function in hemiplegia: a cross-validation study of two assessment methods. Philadelphia, Pa: Harper and Row; 1970.Google Scholar38 Duncan P, Propst M, Nelson S. Blinding was assured by having separate therapists provide the treatment and the assessment. Enrolled subjects were excluded after randomization if they could not tolerate the stimulation, if they were medically unstable, or if they were discharged before completing their treatment and were unable to continue with the treatment at home. Subjects who were discharged before completing the treatment continued to receive the treatment at home under the supervision of a trained family member.AssessmentsAll subjects were characterized with respect to demographics (age, sex, and stroke onset to treatment interval), medical comorbidities (hypertension, coronary artery disease, congestive heart failure, diabetes mellitus, and prior stroke), presence of sensory impairments and hemineglect, side of the hemiparesis, stroke type (hemorrhagic versus nonhemorrhagic), stroke level (cortical versus subcortical), and vascular distribution (anterior versus posterior). Neural substrates for the effect of rehabilitative training on motor recovery after ischemic infarct. All subjects received a total of 15 sessions. Arm function after stroke: measurement and recovery over the first three months. The control group also had more cortical stroke survivors, whereas the treatment group had more subcortical stroke survivors. Exp Neurol.1989; 104:125–132.CrossrefMedlineGoogle Scholar22 Taub E, Miller N, Novack T, Cook E, Fleming W, Nepomuceno C, Conell J, Crago J. Stretch reflex latency changes following repetitive reciprocal and hetero-segmental stimulation in spastic hemiplegic subjects. Subjects who were excluded after randomization were followed up by telephone to assess their disposition (home versus nursing home) and the degree of arm paresis.InterventionThe study institution’s human subjects committee approved the study protocol, and subjects signed informed consent. Benefit of a stroke unit: a randomized controlled trial. Mesh-glove, II: modulation of residual upper limb motor control after stroke with whole-hand electric stimulation. Scand J Rehabil Med.1994; 26:187–190.MedlineGoogle Scholar33 Faghri P, Rodgers M, Glaser R, Bors J, Ho C, Akuthota P. A control study of muscle force recovery in hemiparetic patients during treatment with functional electrical stimulation. Stroke. Stroke.1991; 22:1026–1031.CrossrefMedlineGoogle Scholar2 Kalra L. Continuous and nominal baseline variables were compared with the independent t and χ2 tests, respectively. Int Disabil Studies.1989; 11:89–92.CrossrefMedlineGoogle Scholar49 Heller A, Wade D, Wood V, Sunderland A, Hewer RL, Ward E. Blinded evaluations of upper extremity–related motor function and disability were performed before treatment, after treatment, and at 4 and 12 weeks after treatment by trained physical and occupational therapists, respectively. Arch Phys Med Rehabil.1994; 75:127–132.MedlineGoogle Scholar44 Heinemann A, Linacre J, Wright B, Hamilton B, Granger C. Furthermore, with significant reduction in acute inpatient rehabilitation length of stay and outpatient services, many rehabilitation service providers are forced to focus principally on compensatory strategies to maximize function in the shortest amount of time rather than the restoration of motor control.23One technique that may facilitate motor restoration of stroke survivors is neuromuscular stimulation–induced repetitive movement exercises. Arch Phys Med Rehabil.1994; 75:73–79.MedlineGoogle Scholar34 Dimitrijevic M, Stokic S, Wawro A, Wun C.

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