

Task-Specific Training With Trunk Restraint on Arm Recovery in Stroke

Randomized Control Trial

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Background and Purpose—Task-specific training improves functional outcomes after stroke. However, gains may be accompanied by increases in movements compensating for motor impairments. We hypothesized that restriction of compensatory trunk movements may encourage recovery of premorbid movement patterns leading to better functional outcomes. The goal was to determine whether task-specific training with trunk-restraint (TR) produces greater improvements in arm impairment and function than training without TR in patients with chronic hemiparesis.

Methods—Double-blind randomized control trial of a therapist-supervised home program (3 times per week, 5 weeks) in 30 patients with chronic hemiparesis stratified by arm impairment level (Fugl-Meyer) was performed. Intervention group (TR group) received progressive object-related reach-to-grasp training with prevention of trunk movements. Control group (C) practiced tasks without TR. Main outcome measures were upper limb impairment (Fugl-Meyer Arm Section) and function (TEMPA) and movement kinematics (trunk displacement, elbow extension; Optotrak, 10 trials) of a reach-to-grasp movement. Evaluations were repeated before, immediately after, and 1 month postintervention by blind evaluators.

Results—TR training led to greater improvements in impairment and function compared with C. Improvements were accompanied by increased active joint range and were greater in initially more severe patients. In these patients, TR decreased trunk movement and increased elbow extension, whereas C had opposite effects (increased compensatory movements). In TR, changes in arm function were correlated with changes in arm and trunk kinematics.

Conclusions—Treatment should be tailored to arm impairment severity with particular attention to controlling excessive trunk movements if the goal is to improve arm movement quality and function. (*Stroke*. 2006;37:186-192.)

Key Words: hemiplegia ■ rehabilitation ■ therapy

Poststroke therapeutic interventions leading to functional improvement emphasize intensive task-specific practice¹ reported to facilitate training-induced plasticity.^{2,3} Better functional outcomes are also reported after constraint-induced therapy (CIT) compared with traditional (neurodevelopmental) therapies.⁴ CIT focuses on movement outcome rather than quality resulting from repetition of increasingly difficult tasks. Results of CIT have been documented largely in individuals who are able to perform wrist and finger movements.^{5,6} However, in patients with more severe distal impairments, repetitive task practice without therapist guidance may reinforce compensatory movements.⁷ Given the increasing recognition and interest in documenting activity-induced neuroplasticity, it is necessary to determine whether interventions result in the reappearance of premorbid movement patterns (recovery) or in substitution by novel movement patterns (compensation).

Trunk anterior displacement is a common motor compensation used by patients with hemiparesis for arm transport during bilateral swinging,⁸ reaching,⁹ and for hand orientation during grasping.¹⁰ Despite widespread use of motor compensations, studies of therapeutic effectiveness focus on outcome with less consideration of how functional gains are achieved: by recovery of lost movement elements or by increased use of compensatory movements. Because increased compensation may potentially limit recovery, it is essential to describe training paradigms that both improve motor function while reducing compensations.^{11,12}

Recent studies in patients even with chronic stroke indicate that trunk restraint (TR) can promote improvement in arm coordination patterns.¹³ A single session of 60 repetitions of a reach-to-grasp task during TR led to better retention of newly learned arm movement patterns than practice with verbal instruction alone.¹⁴ What remains to be determined is whether changes persist beyond the intervention period and

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may be related to decreased impairment and improved function. We sought to determine whether domiciliary task-specific training with limitation of trunk compensation led to better arm recovery and function, better arm movement patterns, or both, compared with unrestricted training in patients with chronic hemiparesis.

Methods

Participants

Over 24 months, 497 individuals were identified from discharge lists of 7 hospitals/institutions. Medical records were screened for inclusion criteria: (1) nontraumatic stroke 6 to 48 months previously; (2) impaired arm motor function but able to perform reach-to-grasp movement (\geq Stage 3 Chedoke-McMaster Scale [Arm])¹⁵; (3) aged <85 ; (4) understand simple commands; (5) discharged from active rehabilitation; (6) living in study area. Participants were excluded if they had: (1) occipital/cerebellar lesions; (2) other neurological, neuromuscular or orthopaedic disease; (3) severe comorbidity; (4) perceptual, apraxic or major cognitive deficits; (5) arm contracture/pain. Thirty individuals participated after signing ethics-committee approved consent forms.

Randomization

Stratified randomization ensured that patient characteristics were balanced between groups. Participants were stratified with Fugl-Meyer (FM) Arm scores¹⁶ to less ($FM \geq 50$) or more severe ($FM < 50$) strata and randomly assigned by a research assistant to experimental (TR) or control (nonrestraint, C) groups resulting in 7 and 8 patients in less (mild) and more severe (moderate) strata respectively per group. The research assistant was unknown to evaluators and therapists and was not implicated in patient evaluation or treatment.

Protocol

One evaluator performed a series of clinical arm and hand tests and another recorded reach-to-grasp kinematics before (Baseline), immediately after (Post-test), and 1-month after (Follow-up) intervention. Evaluators were unaware of patient group assignment, and patients were instructed not to discuss their treatment with evaluators.

Intervention

Participants received a 1-hour therapist-supervised home program with object-related reach-to-grasp training 3 times per week for 5 weeks (total=15 sessions). Both groups practiced the same tasks except that in TR, trunk movements (sagittal displacement, rotation) were prevented by body and shoulder belts attached to the chair-back. Scapular elevation/protraction was not restricted. Group C wore unfastened belts without limiting trunk movements. Intervention was based on motor learning concepts of type and scheduling of

feedback as well as practice variability¹⁷ and intensity according to recommendations suggested by recent evidence-based practice guidelines.⁴ Thus, the intervention stressed repetitive practice of meaningful tasks of increasing difficulty, practicing tasks that motivated the patient, and providing enhanced feedback on a summary schedule. It included repetitive functional uni- and bimanual reach-to-grasp tasks using objects varying in size, weight, and shape. In each session, repetition was done in 10-minute blocks. In 3 blocks, use of large and small objects encouraged different grasping configurations (whole-hand, finger-tip). In remaining blocks, use of larger objects promoted bimanual activities. Object placement encouraged the use of desired movement components. Cueing and feedback about missing movement components was given on a summary schedule (ie, movement components, which according to movement analysis studies, are used by nondisabled subjects, but are incomplete or lacking in individuals with hemiparesis). Progression criteria were established by increasing within-block repetitions, increasing object size and weight, as well as increasing the height and distance at which objects were manipulated. Rest periods of 1 to 2 minutes were permitted when necessary to avoid fatigue. Mean number of repetitions per block was 51.2 ± 27.8 (range 20 to 130).

All participants were instructed not to move the trunk during practice. All therapists ($n=3$) received training by the same instructor and used similar verbal cues for patients in both groups. Therapists were unaware of clinical/kinematic test results and specific study goals.

Clinical Assessment

Two primary clinical outcomes characterizing training program effectiveness for improving arm impairment and motor function were FM and Upper Extremity Performance Test (TEMPA), respectively. Isometric force and manual dexterity (Box and Blocks Test [BBT]) were also measured. All scales were valid and reliable.

FM¹⁶ includes 4 motor subitems relevant to the involved upper limb: (1) shoulder/elbow/forearm, (2) wrist, (3) hand, and (4) speed/coordination. Each item was rated on a 3-point scale (0=cannot perform; 1=partially performs; 2=performs fully) for a 66-point maximum. TEMPA¹⁸ includes 4 unilateral activities of daily living tasks (pick up a pot, water pitcher, coins, and small objects) rated as 0 (successful) to -3 (unsuccessful) for score ranging from -12 to 0 (normal function). Some of these tasks were similar but not identical to tasks used in training.

Isometric force¹⁹ of shoulder flexors, elbow, and wrist extensors was evaluated using hand-held dynamometry and handgrip force (dynamometers). Means of 3 trials on affected limb were averaged and expressed as ratios of mean force of the less-affected side (affected/less affected). BBT²⁰ measures the number of 2.5 cm³ cubes transported in 1 minute from one side of a box to another.

TABLE 1. Demographic Data for Groups and Subgroups

	Whole Group		Mild Subgroup (FM \geq 50/66)		Moderate Subgroup (FM<50/66)	
	TR (n=15)	Control (n=15)	TR (n=7)	Control (n=7)	TR (n=8)	Control (n=8)
Gender, n (%)						
Male	10 (67%)	14 (93%)	4 (57%)	6 (86%)	6 (75%)	8 (100%)
Female	5 (33%)	1 (7%)	3 (43%)	1 (14%)	2 (25%)	0 (0%)
Paretic side, n (%)						
Left	9 (60%)	6 (40%)	5 (71%)	3 (43%)	4 (50%)	3 (37%)
Right	6 (40%)	9 (60%)	2 (29%)	4 (57%)	4 (50%)	5 (62%)
Age (y), mean (SD)	68.9 (10.3)	69.4 (10.8)	68.0 (8.5)	67.9 (11.5)	69.6 (12.2)	70.8 (10.7)
Time since onset (mo), mean (SD)	16.7 (9.1)	18.2 (10.7)	12.7 (6.0)	13.7 (7.0)	20.3 (10.3)	22.1 (12.2)
FM score, mean (SD)	47.9 (8.5)	45.1 (14.2)	55.3 (3.7)	57.0 (5.7)	41.4 (5.5)	34.6 (10.5)

Severity cut-offs were based on FM scores according to Fugl-Meyer et al.¹⁶

Kinematic Acquisition and Analysis

Two primary outcome measures of training program efficacy were trunk displacement and elbow extension ranges. Movements were also characterized by range of shoulder flexion, peak arm tangential velocity, smoothness and hand trajectory straightness (secondary outcome measures).

Ten trials of a reach-to-grasp task were recorded. In the initial position, the reaching arm rested on a lateral support with the forearm pronated at elbow height. After a sound, participants reached and grasped a midline cylinder (35 mm diameter, 95 mm height, at height of xiphoid) at a self-paced speed using whole-hand grasping. The distance of the cylinder corresponded to the participant's wrist crease with fully extended elbow (80% arm's length). Arm and trunk kinematic data were recorded with an Optotrak 3010 system (Northern Digital, 120 Hz). Eight infrared-emitting diodes (IREDs) were placed on the (1) index, (2) thumb, (3) first metacarpal head, (4) radial styloid, (5) lateral epicondyle, (6) ipsilateral, and (7) contralateral acromions, and (8) midsternum.

Trunk displacement (mm) was computed as sagittal movement of marker 8. Elbow flexion/extension was the angle between vectors formed by IREDs 4 to 5 and 5 to 6 where full extension equalled 180°. Shoulder flexion/extension was the angle between vectors of IREDs 5 to 6 and the sagittal plane through the ipsilateral shoulder vertical axis (arm alongside body=0°).

Temporal movement characteristics were peak tangential wrist velocity and trajectory smoothness (number of velocity peaks) and straightness (index of curvature: ratio of actual end point path to a straight line).⁷ Arm tangential velocity was computed from velocity vector magnitude, obtained by differentiation of marker positions. Movement beginning/end was defined as a rise/fall of tangential velocity above/below 5% of its peak value. For trajectory smoothness, a velocity peak was defined as a maximum velocity preceded/followed by increasing/decreasing values respectively for at least 20 ms.

Statistical Analysis

Analysis focused on 2 clinical and 2 kinematic primary outcome measures between intervention groups and severity subgroups. Demographic and kinematic characteristics were compared using

Student *t* tests. We postulated that compared with training alone, training with TR would produce (1) greater impairment reduction and functional improvement; (2) greater improvements in motor function by reducing compensatory movement and increasing joint excursions. Between-group and subgroup changes were evaluated with 2 (severity subgroup: mild versus severe) mixed-model ANOVAs and Tukey tests, taking into account baseline differences. Effect sizes were determined with standardized response means,²¹ comparing means to standard deviations of change scores for each effect in each group and 95% confidence intervals. Relationships between clinical and kinematic measures were determined with Pearson correlations for change scores computed as post-test – baseline. Significance levels were <0.05.

Results

Participants

Participants (n=30) were 69±10 years old with stroke occurring 17±10 months previously. Average baseline FM score was 46±12. Fourteen participants had less severe (FM=56.1±4.7, range 51 to 65) and 16 had more severe (FM=38.0±8.8, range 18 to 49) arm impairment. There were no differences in stroke history or demographics between groups or subgroups (Table 1). All participants completed all study phases according to their group assignment.

Effects of Type of Training on Group Performance

Training with TR led to greater decreases in impairment (FM, $F_{2,52}=3.79$; $P<0.035$) and greater improvements in function (TEMPA, $F_{2,52}=2.71$; $P<0.05$) compared with C (Figure 1A and 1B). However, because both groups improved, differences between means and effect sizes were small at post-test and follow-up (Table 2). Kinematic analysis revealed that TR decreased mean trunk displacement by

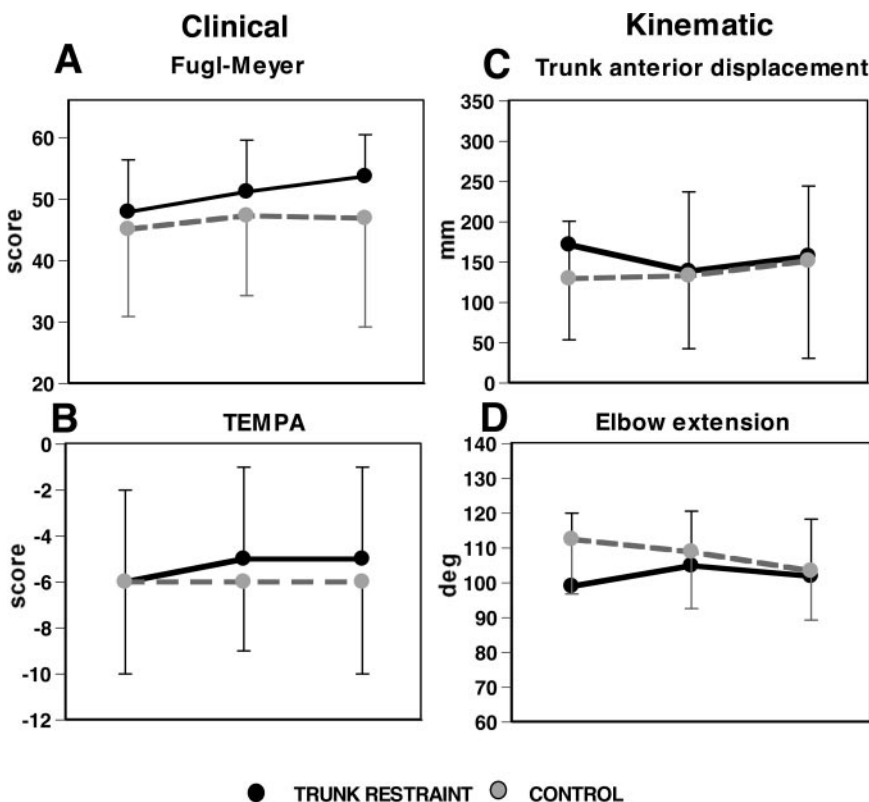


Figure 1. Mean (SD) values of clinical (A and B) and kinematic (C and D) outcome measures by intervention group at baseline, post-test, and follow-up. (A) Fugl-Meyer Arm Scale; (B) TEMPA Score; (C) trunk anterior displacement; (D) elbow extension.

TABLE 2. No. of Participants Who Improved in Each Group*

Outcome	Trunk Restraint (n=15), n (%)	Control (n=15), n (%)	Difference Between Means	Effect Size for Difference (95% CI)
Post-Baseline				
FM score ¹	9 (60%)	7 (47%)	1.0	0.09 (−0.62, 0.80)
TEMPA score ²	6 (40%)	4 (27%)	8.7	0.35 (−0.36, 1.06)
Trunk displacement, ³ mm	10 (67%)	7 (47%)	−36.5	−0.39 (−1.10, 0.32)
Elbow extension, ⁴ deg	6 (40%)	1 (7%)	12.0	0.98 (0.23, 1.73)
Follow-up-Baseline				
FM score ¹	12 (80%)	8 (53%)	4.0	0.35 (−0.36, 1.06)
TEMPA score ²	10 (67%)	6 (40%)	6.6	0.26 (−0.45, 0.97)
Trunk displacement, ³ mm	7 (47%)	2 (13%)	−36.0	−0.38 (−1.09, 0.33)
Elbow extension, ⁴ deg	6 (40%)	1 (7%)	14.0	1.40 (0.61, 2.19)

*Difference between means and effect sizes for primary outcome measures at post-test and follow-up compared to baseline. Based on: ¹>2-point increase; ²>5-point increase; ³≥50 mm decrease; ⁴≥5 deg decrease.

32.8 mm at post-test and 14.2 mm at follow-up, whereas C increased trunk displacement by 3.6 mm and 22.0 mm, respectively. Changes in trunk displacement between groups were not significantly different (Figure 1C). TR increased elbow extension by 5.9° at post-test and 2.9° at follow-up. Compared with C, who decreased elbow extension by 3.6° and 9.1° respectively, increase in TR elbow extension was significant ($F_{2,52}=4.36$; $P<0.02$; Figure 2D) with effect size (ES) of 0.98 and 1.40 respectively (Table 2).

Considering secondary measures, there were no between-group differences, but both groups improved elbow strength (time,

$F_{2,52}=7.27$; $P<0.002$), BBT (time, $F_{2,52}=5.37$; $P<0.01$), peak velocity (time, $F_{2,52}=7.58$; $P<0.002$), trajectory smoothness (time, $F_{2,52}=18.96$; $P<0.001$) and straightness (time, $F_{2,52}=5.79$; $P<0.01$). However, clinical and kinematic measures changed differently depending on severity of hemiparesis.

Training Effects by Severity

In mild subgroups, there were no between-group differences in baseline or intervention-related scores for the 4 primary measures (Figure 2A and 2C). However, given that postintervention increase in joint range was considered an improvement, it was

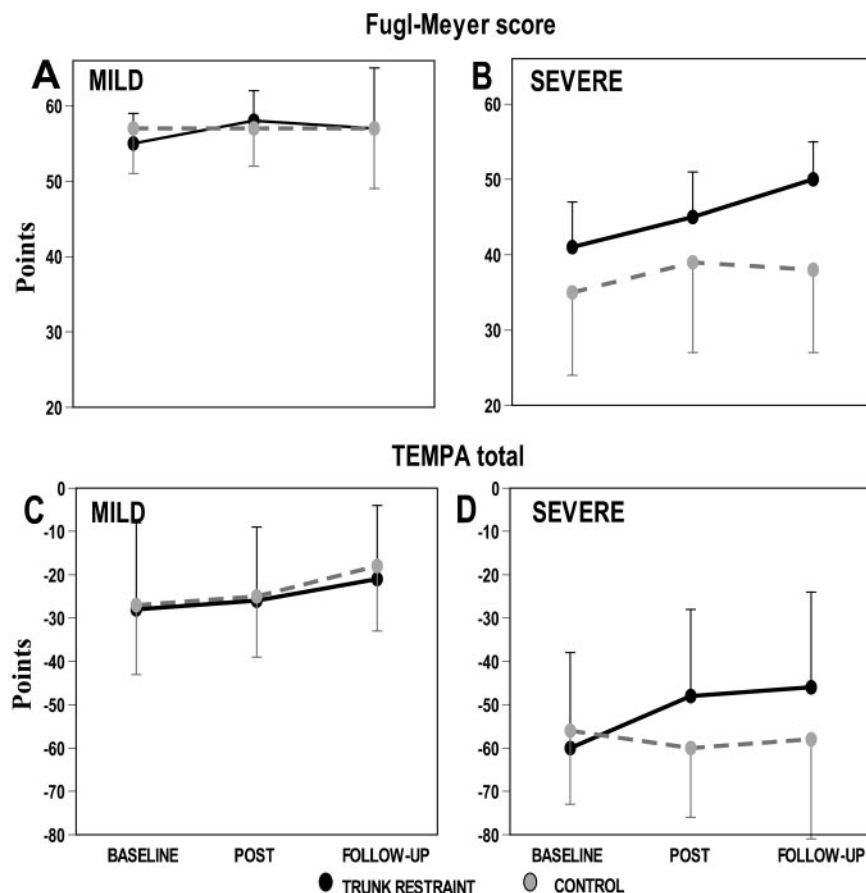


Figure 2. Mean (SD) values of Fugl-Meyer Arm Scale (A and B) and TEMPA scores (C and D) for mild (A and C) and moderate (B and D) subgroups at baseline, post-test, and follow-up.

notable that C mild subgroup had a 10% decrease in elbow extension ($F_{2,52}=3.37$; $P<0.04$) at post-test ($t=2.97$; $P<0.005$) and a 20% decrease in shoulder flexion ($F_{2,52}=3.82$; $P<0.03$) at follow-up ($t=2.90$; $P<0.01$; Table 3).

In moderate subgroups, C initially used more elbow extension ($t=3.26$; $P<0.002$; Table 2) than TR. Both types of training improved Fugl-Meyer scores ($F_{2,52}=6.31$; $P<0.004$) with gains in TR significantly larger than those in C at follow-up (9.0 points compared with 3.4 points, respectively; $t=6.38$; $P<0.001$; $ES=0.68$). Moderate TR subgroup also tended to increase TEMPA scores more than C but this did not reach significance ($F_{2,52}=2.69$; $P<0.07$; $ES=0.26$ at post-test and follow-up, Figure 2B and 2D). In the moderate TR subgroup, in addition to changes in clinical scores there was a reduction in trunk displacement ($F_{2,52}=3.13$; $P<0.003$; $ES=-0.93$ at post-test and -0.66 at follow-up) and increase in elbow extension ($F_{2,52}=3.37$; $P<0.04$; $ES=1.22$ at post-test and 1.36 at follow-up; Figure 3A and 3B). Note that after training, 7/8 patients in TR decreased trunk displacement (Figure 3C) and 6/8 increased elbow extension (Figure 3D).

In contrast, training alone (C) generally had the opposite effects. Without restraint, training significantly increased trunk displacement ($F_{2,52}=2.03$; $P<0.05$) and tended to de-

crease elbow extension. In C, 5/8 patients increased trunk displacement and 6/8 decreased elbow extension.

Considering secondary measures, both moderate subgroups increased elbow extensor strength ($F_{2,52}=5.90$; $P<0.005$) with increases larger in TR (average of 13% post-test and 21% follow-up) than C (average of 6% and 15%, respectively; Table 3). Both severe subgroups also made straighter movements (index of curvature, $F_{2,52}=4.67$; $P<0.02$) at post-test ($t=2.20$; $P<0.04$) and follow-up ($t=4.61$; $P<0.001$). All subjects in severe C subgroup decreased shoulder flexion (8/8), whereas 4/8 in TR moderate subgroup increased shoulder flexion.

Correlations Between Improvements in Clinical and Kinematic Variables

Changes in arm function (TEMPA) correlated differently with kinematic changes according to intervention group. Changes in C were not correlated with changes in any clinical or kinematic measure, whereas those in TR were positively correlated with elbow extension ($r=0.54$; $P<0.05$), shoulder horizontal adduction ($r=0.60$; $P<0.02$) and shoulder flexion ($r=0.67$; $P<0.01$), and negatively correlated with trunk displacement ($r=-0.69$; $P<0.005$). In moderate subgroups,

TABLE 3. Mean (\pm SD) Values of Secondary Clinical and Kinematic Measures at Baseline, Post-Test and Follow-up by Group and Subgroup

Type of Measure	Control			TR		
	Baseline	Post-test	Follow-up	Baseline	Post-test	Follow-up
Clinical						
Elbow extensor strength (affected/nonaffected)						
Whole group	0.56 \pm 0.18	0.64 \pm 0.25	0.64 \pm 0.16	0.59 \pm 0.16	0.69 \pm 0.15	0.70 \pm 0.18
Mild subgroup	0.62 \pm 0.22	0.72 \pm 0.23	0.62 \pm 0.16	0.60 \pm 0.20	0.68 \pm 0.14	0.61 \pm 0.12
Moderate subgroup	0.52 \pm 0.15	0.58 \pm 0.27	0.67 \pm 0.17	0.57 \pm 0.13	0.70 \pm 0.16	0.78 \pm 0.20
BBT						
Whole group	20.7 \pm 12.7	21.9 \pm 12.4	23.2 \pm 12.7	19.5 \pm 14.7	23.1 \pm 13.2	23.0 \pm 13.0
Mild subgroup	32.0 \pm 5.8	31.7 \pm 7.7	32.1 \pm 9.7	29.3 \pm 13.0	32.4 \pm 11.3	30.7 \pm 12.5
Moderate subgroup	10.9 \pm 7.5	13.3 \pm 8.6	11.9 \pm 6.9	11.0 \pm 10.3	15.0 \pm 8.7	16.3 \pm 9.8
Kinematic						
Shoulder flexion, deg						
Whole group	32.6 \pm 14.4	29.9 \pm 16.0	25.7 \pm 15.9	27.8 \pm 16.4	32.5 \pm 15.0	30.1 \pm 11.2
Mild subgroup	37.6 \pm 8.0	38.4 \pm 9.4	31.3 \pm 13.4	39.6 \pm 8.4	40.7 \pm 11.7	36.6 \pm 7.0
Moderate subgroup	28.3 \pm 17.8	22.4 \pm 17.3	20.9 \pm 17.1	17.5 \pm 14.7	25.3 \pm 14.4	24.4 \pm 11.4
Peak velocity, arm						
Whole group	524.7 \pm 112.7	547.2 \pm 152.6	615.6 \pm 193.1	541.3 \pm 134.2	557.8 \pm 172.0	610.5 \pm 177.8
Mild subgroup	563.0 \pm 104.6	575.9 \pm 122.2	708.7 \pm 191.0	566.4 \pm 171.7	635.1 \pm 195.8	667.7 \pm 173.7
Moderate subgroup	490.4 \pm 114.6	522.1 \pm 179.6	534.1 \pm 164.5	519.4 \pm 97.7	490.1 \pm 122.7	560.5 \pm 176.8
Smoothness, # peaks						
Whole group	5.4 \pm 2.3	4.2 \pm 1.7	3.9 \pm 1.8	4.4 \pm 1.9	3.8 \pm 2.0	3.3 \pm 1.7
Mild subgroup	4.0 \pm 2.1	3.1 \pm 1.4	2.9 \pm 1.6	3.5 \pm 1.6	2.9 \pm 1.4	2.9 \pm 1.8
Moderate subgroup	6.6 \pm 1.8	5.1 \pm 1.4	5.2 \pm 2.0	5.2 \pm 2.0	4.6 \pm 2.3	3.6 \pm 1.7
Hand Trajectory straightness						
Whole group	1.5 \pm 0.3	1.4 \pm 0.3	1.4 \pm 0.3	1.5 \pm 0.3	1.4 \pm 0.3	1.4 \pm 0.2
Mild subgroup	1.24 \pm 0.15	1.20 \pm 0.12	1.23 \pm 0.09	1.33 \pm 0.16	1.29 \pm 0.11	1.33 \pm 0.15
Moderate subgroup	1.74 \pm 0.28	1.62 \pm 0.21	1.63 \pm 0.40	1.63 \pm 0.40	1.57 \pm 0.32	1.43 \pm 0.31

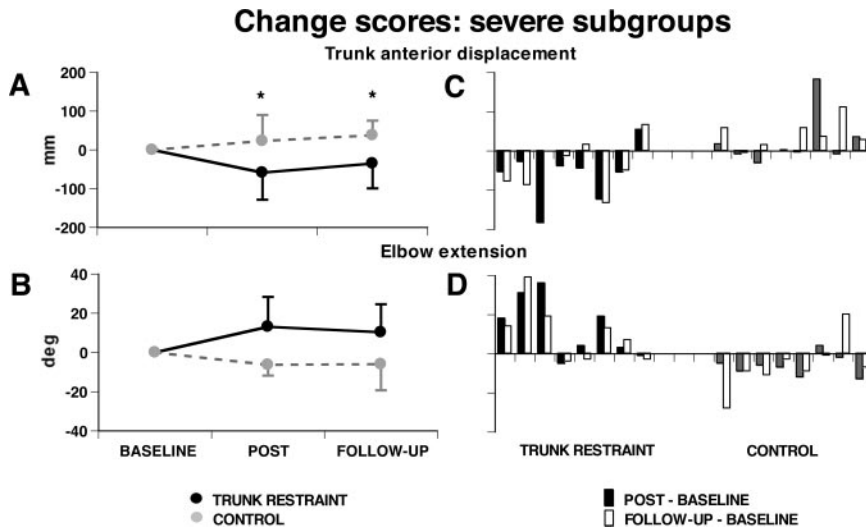


Figure 3. Mean (SD; A and B) and individual change scores (C and D) at post-test (filled) and follow-up (open bars) compared with baseline for trunk anterior displacement (A and C) and elbow extension (B and D) in moderate subgroups. For histograms (C and D), data from TR (left) and C (right) are arranged by clinical severity from left to right. Note opposite effects of training between groups.

the increase in TEMPA in C but not TR correlated with increased trunk displacement ($r=0.96$; $P<0.001$).

Discussion

We tested the hypothesis that task-related training with TR would improve arm function and active joint range more than task-related training with trunk unrestrained. This hypothesis was based on previous findings that excessive trunk recruitment and movement limitations were correlated with the degree of stroke severity during unrestrained reaching.^{9,13}

Several high quality randomized controlled trials have reported functional gains following task-specific training.^{22,23} Contrary to most upper limb intervention studies reporting better outcomes in patients with less severe impairment, our results suggest that patients with more severe upper limb impairment may also make significant improvement with an appropriate intervention. Our results reinforce findings that gains occur differently in patients with different levels of hemiparesis severity. Specifically, without trunk restraint, mildly-affected patients made only minimal gains whereas those with moderate impairment improved while increasing motor compensations. Increases in compensatory movements with unrestricted practice has previously been reported in studies of low functioning adult patients⁷ and in children with mild cerebral palsy after 3 weeks of constraint-induced therapy.²⁴ The current study supports the idea that compensations may be considered maladaptive because they may lead to nonoptimal movement patterns hindering further improvement and potential recovery of compromised body segments/muscles.^{11,12}

Changes in Patients with Mild Impairment

In patients with mild arm impairment, task-related training increased movement velocity and smoothness with only marginal effects on arm function. Overall, there was no added benefit of TR in this group. A previous study showed that patients with mild paresis benefited from task-related training in acute recovery stages.²² In contrast, in our study, mildly-affected patients in the chronic stage benefited little from task-related training. It is unlikely that this lack of improvement resulted from the training not being challenging enough.

Tasks were chosen according to patients' needs and abilities and were progressed in each session to maintain task difficulty. However, training may not have addressed the right motor deficits. Thus, for patients who have achieved a certain critical level of functional recovery, further recovery may occur through targeting of other motor elements such as speed, coordination, and dexterity.

Changes in Patients With Moderate Impairment

In moderate subgroups, task-related training had opposite effects depending on whether tasks were practiced with or without trunk restraint. Indeed, similar functional gains were accomplished by improvements in movement patterns in TR and greater motor compensations in C. These results may inform decisions about effectiveness of task-related training which may be improved if attention is concurrently paid to reducing compensations and targeting patients with more severe symptoms. Note however that our sample was small and did not include very severe (FM <20) or subacute patients.

In this study, significant gains in arm function occurred in patients with chronic stroke. Although arm motor improvement occurs most rapidly within the first months poststroke, intervention studies have shown that meaningful gains can occur even in chronic stroke if the system is appropriately challenged.²⁵ Persistence of compensatory movements may lead to maladaptive strategies becoming part of the daily movement repertoire. Compensatory movement strategies may be very difficult to unlearn,²⁶ frustrating efforts to improve movement for both patient and therapist. Thus, it seems reasonable to suggest that therapeutic interventions for movement recovery be combined with minimization of compensatory movements early after stroke onset to prevent their development.

Conclusion

Limitation of compensatory trunk movement may be an essential element to include during task-related training of reaching and grasping, particularly for chronic patients with moderate-to-severe arm hemiparesis.

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