

A Review of Bilateral Arm Movement Approach for Upper Extremities Treatments in Stroke

雙側上肢動作對於中風病患的上肢康復治療之探討

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Introduction

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Hemiparetic upper extremity recovery in stroke

- 60% of the chronic stroke patients have motor dysfunction in their upper extremity (上肢的動作功能缺失)
- 5% of them demonstrate complete functional recovery (完全的功能恢復) (Dobkin, 2005)
- The impairment of upper extremity affects
 - Gross motor (大動作)
 - Fine motor (細動作)
- Bilateral upper limbs movement (雙側上肢動作) is essential to finish the tasks in daily living.
 - Grooming task (盥洗), bilateral movements are needed to dry the towel.

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Hemiparetic upper extremity recovery in stroke

- Normal subjects
 - coordinate the movements of the upper limbs (雙側上肢的協調) very well
- Stroke patients
 - Appear obvious bilateral motor dysfunction (雙側動作缺失) caused by imbalanced cortical excitation and inhibition (大腦皮質刺激和抑制之間的不平衡) (Mudie & Matyas, 2000)

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An overview of upper extremities treatment approaches in stroke

- Constraint induced movement therapy (局限誘發療法)
 - Forced to use their affected upper extremity (強迫使用患肢) to perform different kind of tasks, in order to facilitate motor recovery of the affected arm (Sterr, Szameitat, Shen, & Freivogel, 2006; Taub & Uswatte, 2003).
 - only apply to the patients who have mild impairment in upper extremity (輕微缺失)
- Using therapeutic device such as robotics
 - train independently
 - mass repetitive movement practice

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A comparison between the Conventional Bilateral Treatment (傳統雙側治療) and the Bilateral Arm Movement Approaches (雙側上肢動作訓練)

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Conventional bilateral treatment

- Brunnstrom's movement therapy (Sawner & LaVigne, 1992)
 - no voluntary + spasticity
 - associated reaction (聯合反應) → flexor & extensor tone → voluntary movement (自主動作)
- Neurodevelopmental Treatment (NDT) (Davies, 1993)
 - clasped hands → inhibit the spastic pattern + experience the normal sensations of the functional movements (體驗正常動作的感)

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Bilateral Arm Movement Approach

- New perspective on bilateral movement training.
 - inter-limb coupling (肢體間的聯結) in stroke patients
 - applying bilateral arm movement training could promote the function of upper extremity.

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What bilateral arm movement emphasizes?

- Two upper extremities
- Simultaneously (同時)
 - initiate and perform the bilateral task at the same time
- symmetrical movements (對稱性動作)
 - similar spatiotemporal trajectories
- separate from each other (雙側上肢分開動作)
- assisted / non-assisted
 - Device: Robotic arms (機械手)
 - Sensory feedbacks: auditory curing (聲音提示)
 - and neuromuscular stimulations

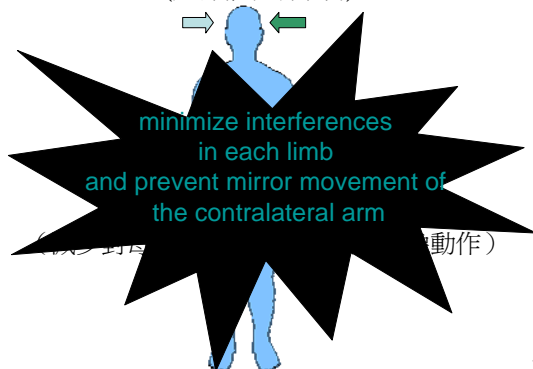
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Rationale behind the Bilateral Arm Movement Approach (雙側上肢動作訓練原理)

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Interhemispheric inhibition

(大腦間的抑制)



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Interhemispheric disinhibition

- During bilateral movement
 - motor organization occurs in both hemispheres
 - allocate less attention or energy
 - couple the limbs → as one functional unit (連結兩側肢體成一功能單位) (Mudie & Matyas, 2000)
 - undamaged hemisphere → damaged hemisphere and prompt the neural plasticity (誘發神經重塑) (Carson, 2005)

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Interhemispheric disinhibition

- Brain region related to Bilateral arm movt.
(Carson, 2005)
 - primary motor cortex (主要運動皮質區)
 - supplementary motor area(補充運動區)
 - non-primary motor areas(非主要運動皮質區)
 - basal ganglia (基底核)
 - Cerebellum (小腦)

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Review of literature related to bilateral arm movement approach (雙側上肢動作法的文獻回顧)

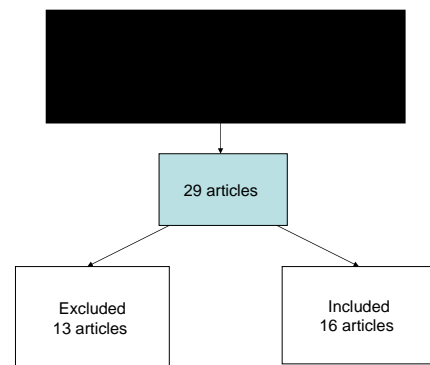
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Aim of review

- Past review
 - 2006 (articles were published until the year 2005)
 - bilateral arm movement training is effective for sub-acute and chronic stroke patients
- bilateral arm movement training has been used increasingly in these recent years
 - especially for the bilateral robotic therapy

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Method of search strategy



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Effectiveness of different Bilateral Arm Movement Approaches

- Up to present
 - miscellaneous trainings for bilateral arm movement approach → different training protocols.
- Based on the level of assistance (協助的程度) or auxiliary sensory feedback (輔助性感覺刺激)
 - categorized in to training without facilitation and with facilitation.

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Pure bilateral tasks with no facilitations

Study	N, groups	Training protocol	Training duration	Length of training period	Outcome measures	Results
(Mudie & Matyas, 2000)	4,1	Block placement and simulated drinking	N/A	6 weeks (30 sessions)	Kinematic analysis	All participants demonstrated highly significant improvement in movement pattern.
(Lewis & Byblow, 2004)	6,1	3 upper extremities tasks (eg. Block placement, peg activities, simulated drinking)	33 trials	4 weeks (20 sessions)	FMA	No FMA score difference between unilateral and bilateral training
(Summers et al., 2007)	12,2	Dowel placement task	50 trials	6 days	MAS and Kinematic analysis	5 out of 6 participants in bilateral training group improved in MAS score. The difference between unilateral and bilateral group reached significant level.

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Bilateral tasks with auditory cueing(BATRAC)

Study	N, groups	Training protocol	Training duration	Length of study	Results
(Whitall, McCombe Waller, Silver, & Macko, 2000)	14,1	Repetitive pushing/pulling movement	50 min (Four 5-minute blocks)	6 weeks (18 sessions)	FMA score improved 18%, WMFT score improved 12% and UMAQS scores were 52% higher after intervention. Benefits sustained 8 weeks after training.
(Luft et al., 2004)	21,2	Repetitive pushing/pulling movement	50 min (Four 5-minute blocks)	6 weeks (18 sessions)	Significantly increased in FMA scores. (Excluding 3 patient not showing fMRI changes)
(McCombe Waller & Whitall, 2004)	10,1	Repetitive pushing/pulling movement	50 min (Four 5-minute blocks)	6 weeks (18 sessions)	Significant gains in FMA, WMFT and UMAQS were seen after training.
(Richards, Senesac, Davis, Woodbury, & Nadeau, 2007)	14,1	Repetitive pushing/pulling movement	135 min (Nine 5-minute blocks)	2 weeks (8 sessions)	No significant changes in FMA and WMFT. Participant reported increased paretic U/E use (Motor Activity Log)

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Bilateral tasks with neuromuscular stimulation

Study	N, groups	Training protocol	Training duration	Length of training period	Outcome measures	Results
Cauraugh & Kim, 2002	25,3 (Bilateral, unilateral, control)	Wrist/ fingers extension	90 min	2 weeks (4 sessions)	Box and Block test	The improvement in bilateral training group is 7 times better than control group.
Cauraugh & Kim, 2003	26,2	Wrist/ fingers extension	90 min	2 weeks (4 sessions)	Box and Block test	Significant improved the number of blocks moved.
Cauraugh, Kim & Duley, 2005	26,3(Bilateral, unilateral, control)	Wrist/ fingers extension	90 min	2 weeks (4 sessions)	Kinematic analysis	The bilateral group from pretest to posttest improved their movement time, peak velocity and deceleration time.

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Bilateral tasks with Robotics

Study	N, groups	Training protocol	Training duration	Length of training period	Outcome measures	Results
(Lum, Burgar, Shor, Majumdar, & Van der Loos, 2002)	27,2	12 targeted reaching movement	60 min	8 weeks (24 sessions)	FMA BI FIM Strength Kinematic analysis	Significant differences in FMA (proximal) after 1 & 2 months. Larger increase in strength and reach extent after 2months. Improvement of FIM at 6-month follow-up.
(Hesse, Schulte-Tiggas, Konrad, Bardeleben, & Werner, 2003)	12,1	Forearm supination/ pronation, wrist flexion/ extension	15 min	3 weeks (15 sessions)	RMA MAS	Significant decrease in the MAS scores of wrist and fingers. 5 out of 12 participants improved in the RMA scores.
(Stinear & Byblow, 2004)	9,1	Active-passive wrist flexion/ extension	60 min	4 weeks (20 sessions)	FMA Strength	5 patients increased their FMA scores by 10% or more after the intervention. No statistically significant changes in strength.

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(Hesse et al., 2005)	44,2	Forearm supination / pronation, wrist flexion/ extension	20 min	6 weeks (30 sessions)	FMA MAS	Significantly more gains in FMA and muscle power than the control group.
(Lum et al., 2006)	30,4	12 targeted reaching movement	60 min	4 weeks (15 sessions)	FMA MSS FIM Strength MAS	Less gains from bilateral therapy alone. Significant gains in combine (unilateral and bilateral) training and unilateral training in FMA, FIM and strength.
(Chang, Tung, Wu, Huang, & Su, 2007)	20,1	Repetitive symmetric push /pull movement	30 min	8 weeks (24 sessions)	FMA FAT MAS Strength Kinematic analysis	Significant differences in FMA and grip, push and pull strength (post-test, retention>pretest) Significant difference in movement time, peak velocity, percentage of time to peak velocity and normalized jerk score (post-test>pretest) FAT and MAS did not show significant difference.

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Discussion

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A comparison of different types of treatment approaches

	Without facilitation	With facilitation		
	Pure bilateral tasks training	BATRAC	Bilateral tasks with ANS	Bilateral tasks with Robot
Target patients	Chronic (mild motor impairment)	Chronic	Chronic (voluntary movement in paretic arm)	Subacute to Chronic
Total Training duration	Varied	15~18hr	6 hr	3.75~24 hr

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	Pure bilateral tasks training	BATRAC	Bilateral tasks with ANS	Bilateral tasks with Robot
Advantages	Generalization	Provide feedback, constant frequency	Provide feedback	High intensity of therapy, Saving manpower, Flexible protocol
Disadvantages	Limited target group	Limited target group	Limited target group	Apparent gains occur only at the early phase of training, Expensive

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Implications in future rehabilitation for upper extremity in stroke

- Bilateral arm movement
 - lower motor function
 - assistance is provided
- Coordination movement
 - voluntary movement (自主動作) achieved
 - enhance the functional use in daily life.

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Implications in future rehabilitation for upper extremity in stroke

- Since there is no structural protocol (統一和結構性的程序)
- For bilateral arm movement approach
 - take notice of the level of intensity(強度), duration(持續時間)of training and most effective combination of supplementary assistive protocols.

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Conclusion

- A systemic review and several studies showed improvement on motor performance, muscle strength and spasticity in affected upper extremity.
- There are still some studies could not find any additional improvement after bilateral arm training.
- Prolonged treatment effect is not clear.
- Further study with RCT is required to assess its effectiveness and find out the most effective protocol.

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