Contemporary Perspectives on the Application of Constraint Induced Movement Therapy

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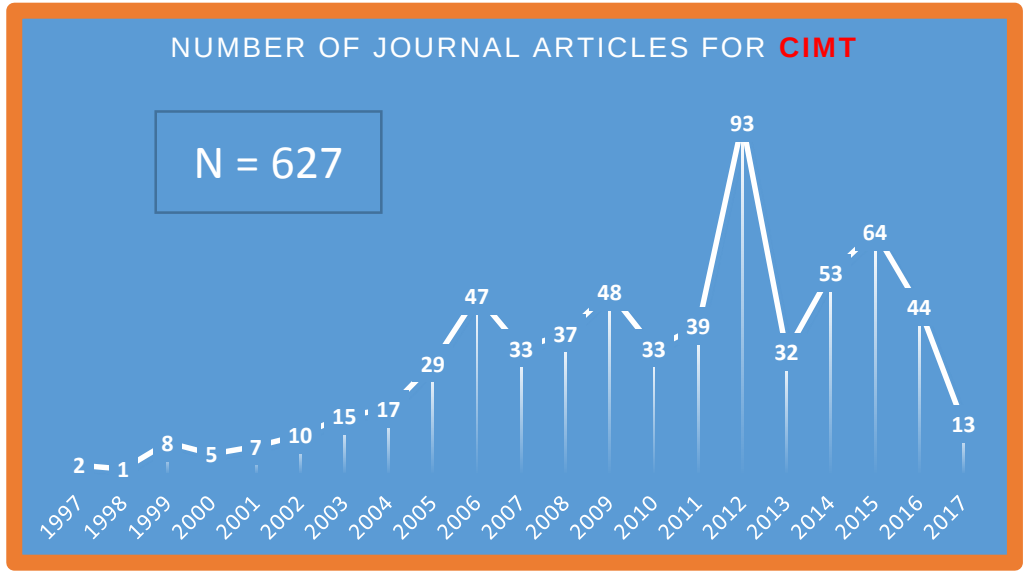
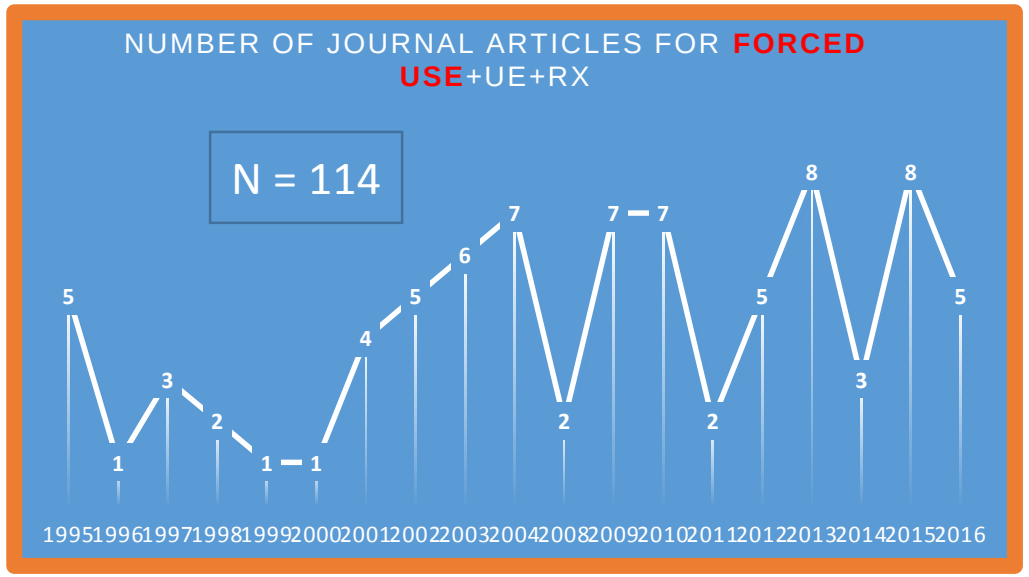
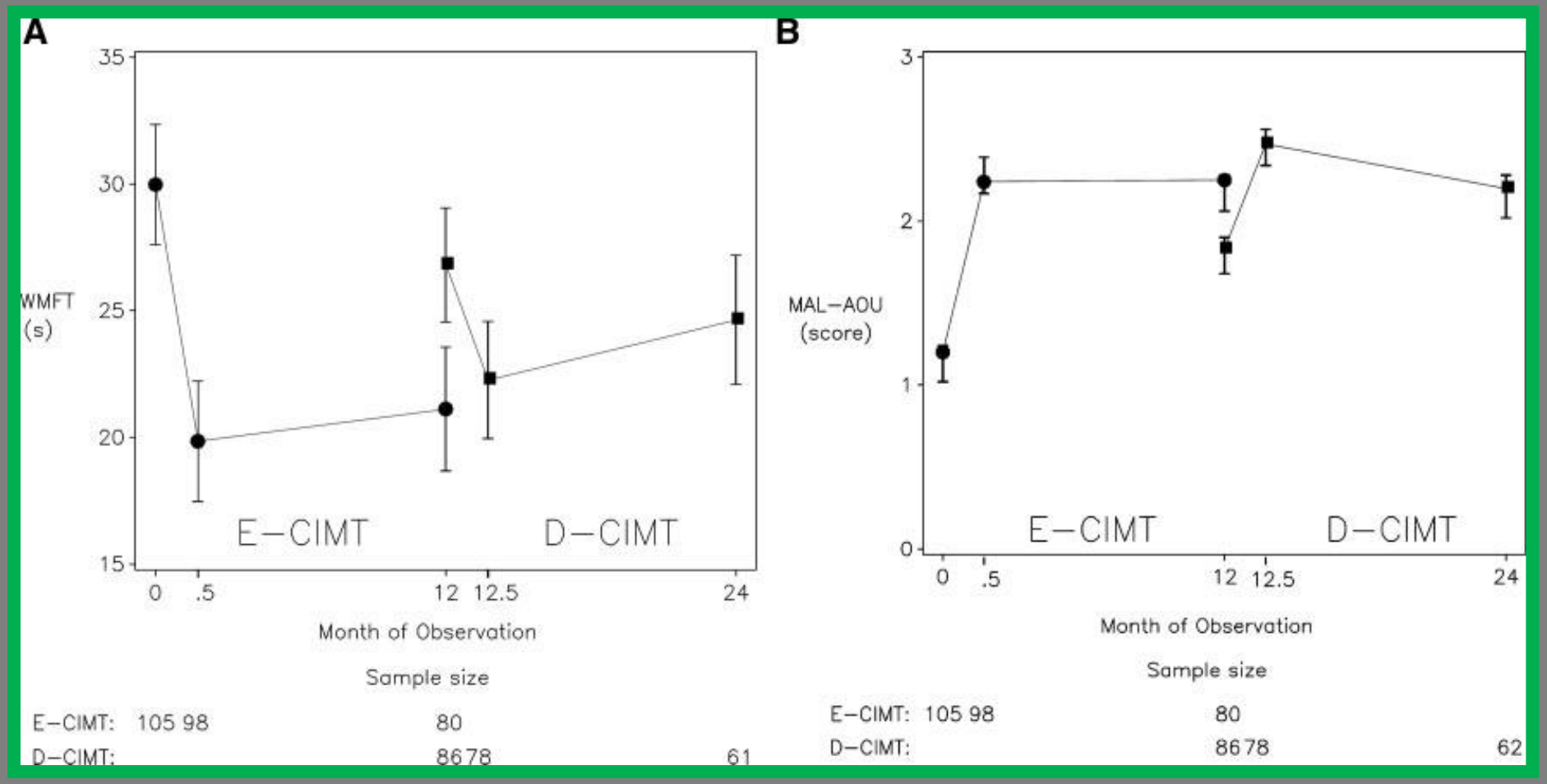
Summary Points: “The Take Home”

- Constraint-Induced Movement Therapy (CIMT) has met with favorable success in select stroke survivors
- Elements of CIMT formed part of the foundation for elements within the ICARE Clinical Trial
- Emphasizes on unimanual training must be balanced against the reality of bimanual function
- Concepts embedded with the Accelerated Skill Acquisition Program (ASAP) expand the concept of “physical” therapy to embrace multiple behaviors
- “Reaching” a common end point across interventions for those who have movement out of synergy


NUMBER OF JOURNAL ARTICLES FOR CIMT
N = 627
2 1 8 5 7 10 15 17 29 47 33 37 48 33 39 93 32 53 64 44 13
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017


NUMBER OF JOURNAL ARTICLES FOR FORCED USE+UE+RX
N = 114
5 1 3 2 1 1 4 5 6 7 2 7 7 2 5 8 3 8 5
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2008 2009 2010 2011 2012 2013 2014 2015 2016

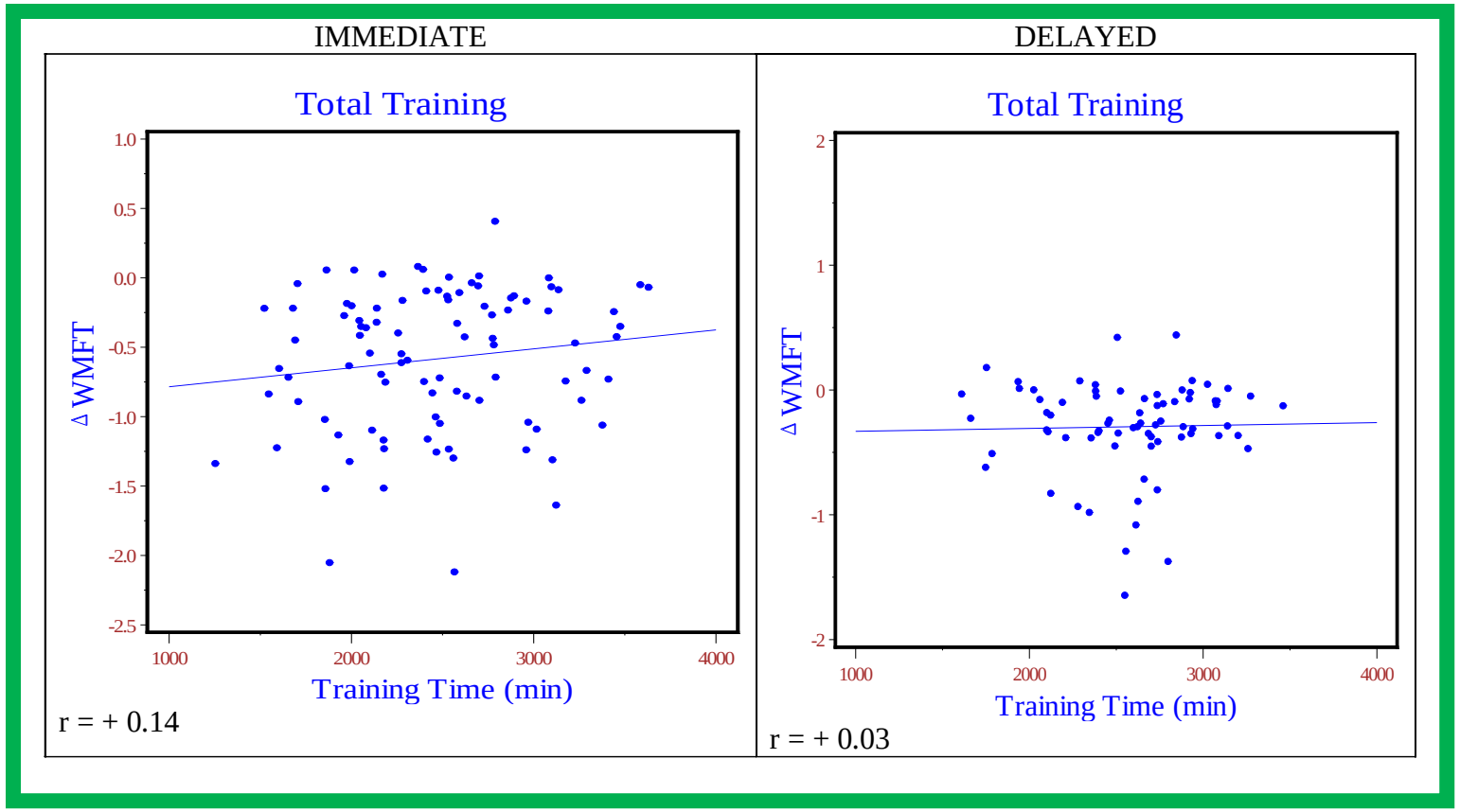
Wolf et al: Stroke, 2010; 41:2309-2315



INTENSITY OF TRAINING

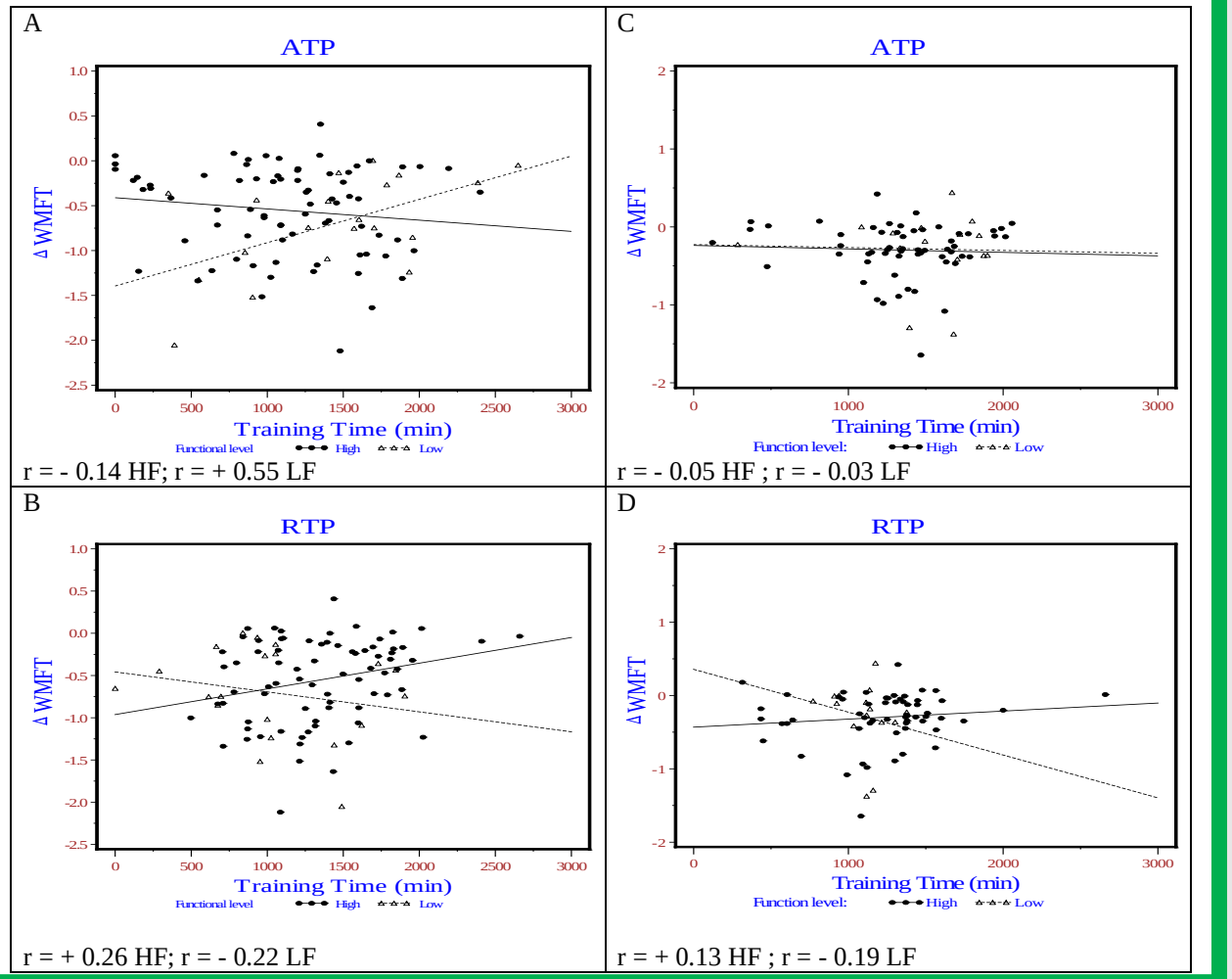
No significant relationship was seen between the intensity of training and ΔlmWMFT in the immediate group (p= 0.16)

Wolf et al, Restorative Neurol & Neurosci; 2007;25:549-562.

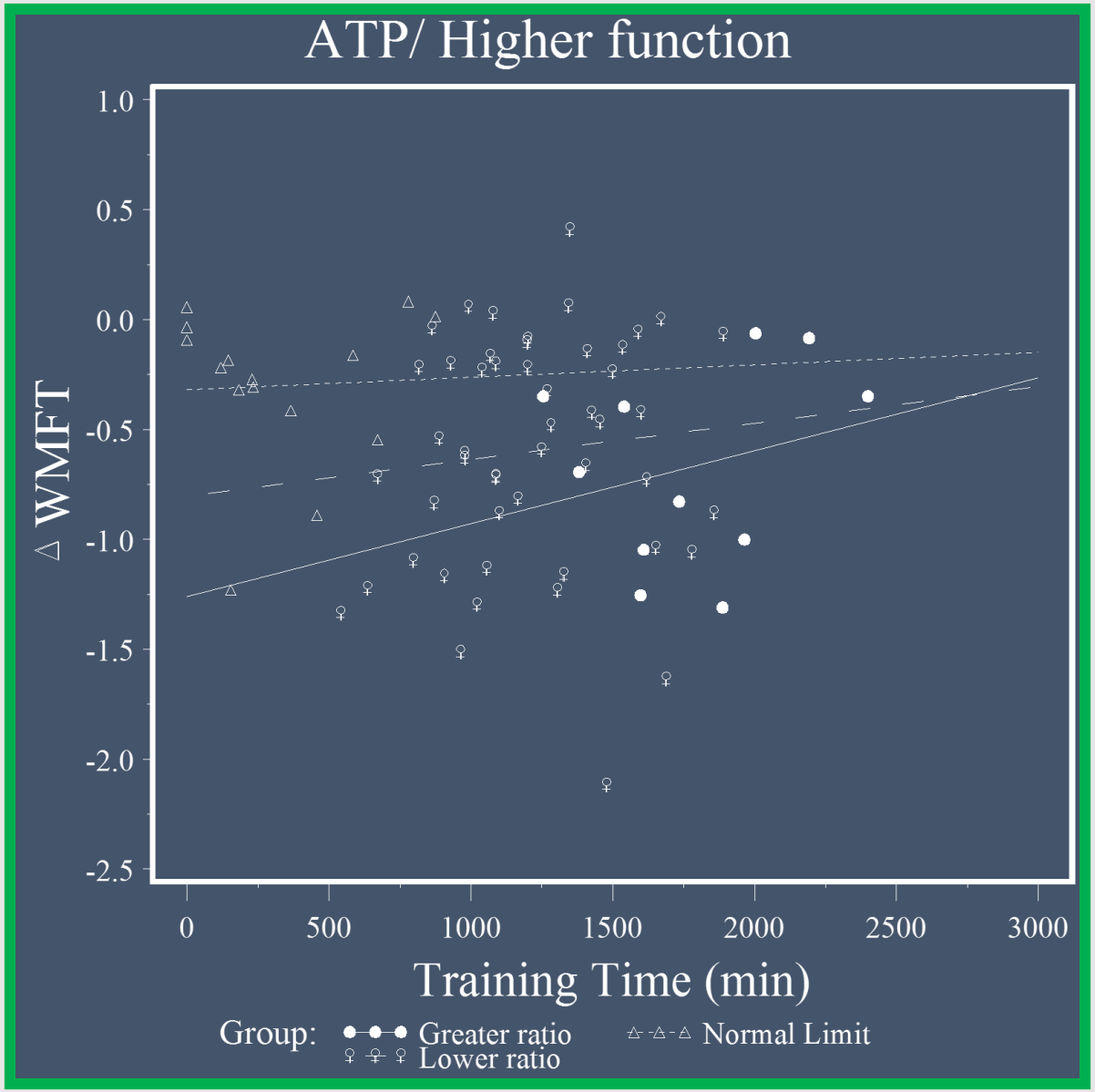


INTENSITY OF TRAINING

HOWEVER, immediate HF participants showed an inverse relationship between time spent in RTP and improved WMFT scores (p = 0.02) and immediate LF participants showed an inverse relationship between time spent in ATP and improved WMFT scores. (p = 0.01)



HF = more ATP & < 1500 min



Wolf SL et al: Neurorehab Neural Repair, 2012; 26:178-187

Table 4: Overall CIMT-I (Immediate) and CIMT-D (Delayed) groups' changes from baseline to 2 weeks later for more affected side

		CIMT-I		CIMT-D	
TASK	Task #	Improved	No Change	Improved	No Change
Forearm to Table n=3	1	0	0	2	1
Forearm to Box n=10	2	5	3	2	0
Extend Elbow Side n=22	3	5	2	8	7
Extend Elbow Weight n=14	4	7	0	3	4
Hand to Table (Front) n=5	5	0	0	2	3
Hand to Box (Front) n=22	6	4	1	4	13
Reach & Retrieve n=3	8	1	0	0	2
Lift Can n=44	9	13	8	4	19
Lift Pencil n=42	10	13	6	1	22
Lift Paper Clip n=44	11	17	5	3	19
Stack Checkers n=71	12	24	9	7	31
Flip Cards n=32	13	10	2	4	16
Turn Key in Lock n=39	15	6	8	3	22
Fold Towel n=33	16	5	2	8	18
Lift Basket n=61	17	10	15	7	29
TOTALS: n=445		**120**	**61**	**58**	**206**

Wolf SL et al: Neurorehab Neural Repair, 2012; 26:178-187.

Table 2: P-values for changes in task completion by group, visit and group-visit interaction

(C= Condition, V=Visit) for the more affected side

		Adjusted		
Task	**Task #**	**Group**	**Visit**	**C x V**
Forearm to Box	2	0.0608	0.0699	0.0182
Extend Elbow Side	3	0.0342	0.0193	0.9445
Extend Elbow Weight	4	0.0488	0.0609	0.0336
Hand to Box (Front)	6	0.0003	0.1936	0.2932
Lift Can	9	0.0359	0.0006	0.0256
Lift Pencil	10	0.0043	0.0359	<.0001
Lift Paper Clip	11	0.1007	0.0105	0.0023
Stack Checkers	12	0.0002	<.0001	0.0002
Flip Cards	13	0.0005	0.0204	0.0528
Turn Key in Lock	15	0.0007	0.4349	0.0602
Fold Towel	16	<.0001	0.0203	0.2422
Lift Basket	17	0.0608	0.0187	0.4968
Total incompletes		0.0001	<.0001	<.0001

Wolf SL et al: Neurorehab Neural Repair, 2012; 26:178-187.

Table 3: Number of regressions by tasks for CIMT-I (Immediate) & CIMT-D (Delayed) groups for more affected side

		Regressed	
Task	**Task #**	**CIMT-I**	**CIMT-D**
Forearm to Table	1	0	0
Forearm to Box	2	0	1
Extend Elbow Side	3	1	1
Extend Elbow Weight	4	1	4
Hand to Table (Front)	5	1	0
Hand to Box (Front)	6	1	1
Reach & Retrieve	8	0	1
Lift Can	9	1	1
Lift Pencil	10	0	5
Lift Paper Clip	11	3	3
Stack Checkers	12	1	2
Flip Cards	13	1	2
Turn Key in Lock	15	0	3
Fold Towel	16	1	1
Lift Basket	17	2	0
Total		**13**	**25**

Variations in application of CIMT

Timing of administration

- Acute/Subacute/Chronic
- Clinic vs. Home-based

Wearing mitt

- Forced use
- 90% waking hrs (“signature CIMT/ExCITE”)
- mCIMT – 5 hrs/day
- Distributed CIMT – 9.5 hrs/day

Intensity of practice

- EXCITE: 6 hrs/day, 5 days/wk for 2 wks
- mCIMT: 30 min/day, 3 days/wk for 10 wks
- Distributed CIT: 3 hrs/day for 20 days

Type of practice

- Shaping (adaptive task practice)
- Repetitive task practice
- Traditional therapy

Variations of CIMT

NAME	DESCRIPTION
Forced Use (Wolf) **USA**	All day and home based, 2 wks
Signature (Taub) **USA**	8 hrs/day (1.5 – 4.5), 2 weeks (90%???)
Modified (Page) **USA**	3 .5 OT/week, 5 weeks, 5 hrs/d home 10 weeks
Distributed (Wu) **Taiwan**	2hr/d, 5d/wk, 3 weeks
Modified (Treger) **Israel**	1 hr rehab/d, 2 weeks , restraint 4hrs/d
CIMTHome vs. Signature (Barzel) **Germany**	CIMT Home = 4 weeks, daily 2 hours with family member
Modified –Home (Tariah) **Jordon**	Home by therapist, 2hr/d, daily, 2 months
Modified CIMT (Myint) **Hong Kong**	10 days 4 hrs/d. sling 90% waking hours
Consistent Protocol?	**Head –to- head comparison**

Constraint Induced Movement Therapy (Forced Use)

- PRO
  - Preliminary evidence that this intervention yields meaningful functional gains in patients with chronic stroke having specific movement criteria (23-30% of the population)
  - Re-energizes research and clinical approaches targeting “repetitive task practice” within a functional context
  - Fosters further investigation into CI therapy among patients with acute and sub-acute stroke
  - Promotes research activities in other dx categories
  - Spawns research into mechanism (TMS/fMRI co-registration)

Constraint Induced Movement Therapy (Forced Use)

- CON
  - Practicality of individualized training
  - Need for valid outcome measures
  - Cost-effective?
  - Validation across clinics/research centers
  - Potential misrepresentation (magnitude of effect)
  - Mismatch between statistical and functional significance
  - No true effectiveness studies

Constraint Induced Movement Therapy (Forced Use)

- UNCERTAIN
  - Persistence of effect
  - Cultural factors contributing to adherence
  - Behavioral and social influences across cultures and across time post-stroke (i.e., does CI therapy for acute, sub-acute and chronic stroke patients present with very different problem sets influencing outcome)?
  - Distribution of training (What constitutes “intensity”?)
  - Best training methods (shaping vs. repetitive task practice)

Unimanual – Bimanual Training

Unimanual

- Limited activities (10-20%)
- Labor intensive
- Validate and replicate procedures
- De-emphasize proximal joint motion while concentration on “end organ effector”

Bimanual

- Most ADLs
- Coordinated versus reciprocal?
- Engaging or frustrating?
- Dominance prevails?

Training

- Whitall BATRAC studies (2000, 2011) – proximal joints, but superior to ther. ex.
- DeJong and Lang (2012): 1 session and no difference in pre-post kinematics or kinetics
- Wu (2011): Bilateral and dCIMT similar effect on smoothness with bilateral >force generation and dCIMT>functional ability and MAL (AOU).
- Either/OR?.....sequential……integrated…..

Important aspects to consider:

- Appropriate screening
  - – too low AND too high
  - -Motivation
  - -Cognition/Safety
  - -Family support
  - -Appropriate and *ethical* allocation of resources
- Timing of intervention
- Involvement of family
- Involvement of other disciplines

Kwakkel, Veerbeek van Wegert, Wolf: Constraint-induced movement therapy after stroke. Lancet (Neurology), 2015, 14:224-234.

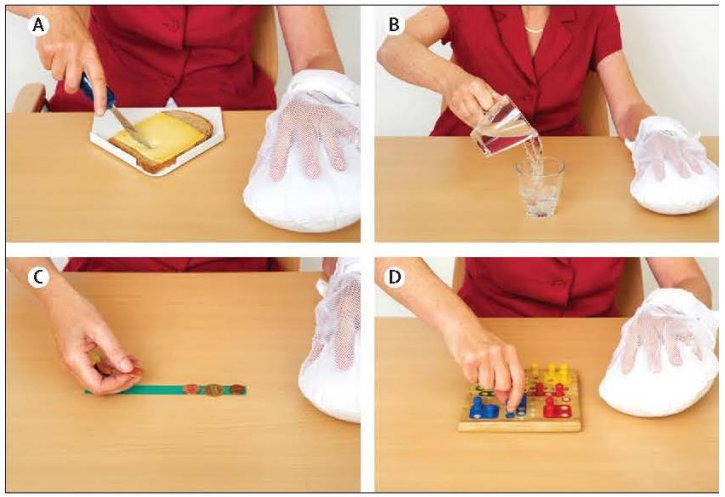


Figure 1: Task-oriented practices with the paretic limb in constraint-induced movement therapy (CIMT)
Practices include: (A) cutting bread, (B) pouring water, (C) picking up and placing back money, and (D) playing a game. Use of the unaffected limb is restricted by a padded mitt.

Panel: **Definitions and description of rehabilitation terms**

Original constraint-induced movement therapy
A form of rehabilitation therapy that consists of three components: immobilisation of the non-paretic arm with a padded mitt for 90% of the waking hours; task-oriented training with a high number of repetitions for about 6 h a day; and, behavioural strategies to improve both compliance and transfer of the practiced activities from the clinical setting to the patient's home environment.

Modified constraint-induced movement therapy (mCIMT)
This therapy does not include the three components of original CIMT, but is restricted to repetitive, task-specific training of the paretic arm, including shaping procedures, applied in a different dose, combined with constraining of the non-affected hand by a padded mitt, glove, or splint.

Forced use therapy
An intervention that is limited to immobilisation of the non-paretic arm to increase the amount of use of the paretic limb. No formal behavioural training (shaping) is specified in the treatment protocol.

Intensity of original and modified CIMT
Number of hours spent in supervised exercise therapy.

Treatment contrast
Time spent on exercise therapy for the experimental group minus that for the control group.

See Online for appendix

Kwakkel, Veerbeek van Wegert, Wolf:
Constraint-induced movement therapy after stroke.
Lancet (Neurology), 2015, 14:224-234

Informational Database

- CIMTt = 51 RTCs (15/51 = < 3 mo. Post-stroke (N= 1784)
- mCIMT = 44 RTCs (N=1397)
- Forced use = 6 RTCs (N=165)

Kwakkel et al: Lancet Neurology, 2015; 14:224-234.

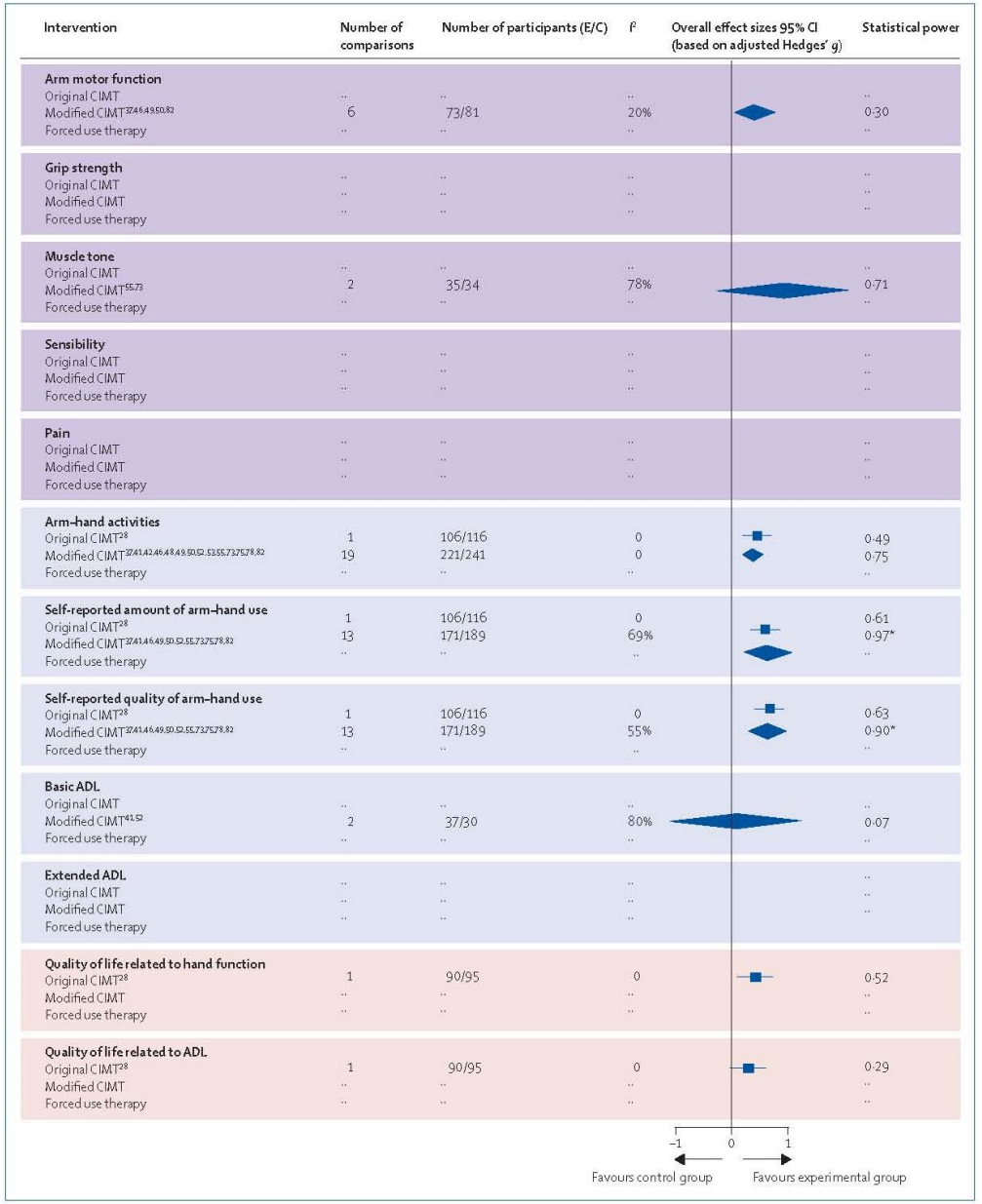
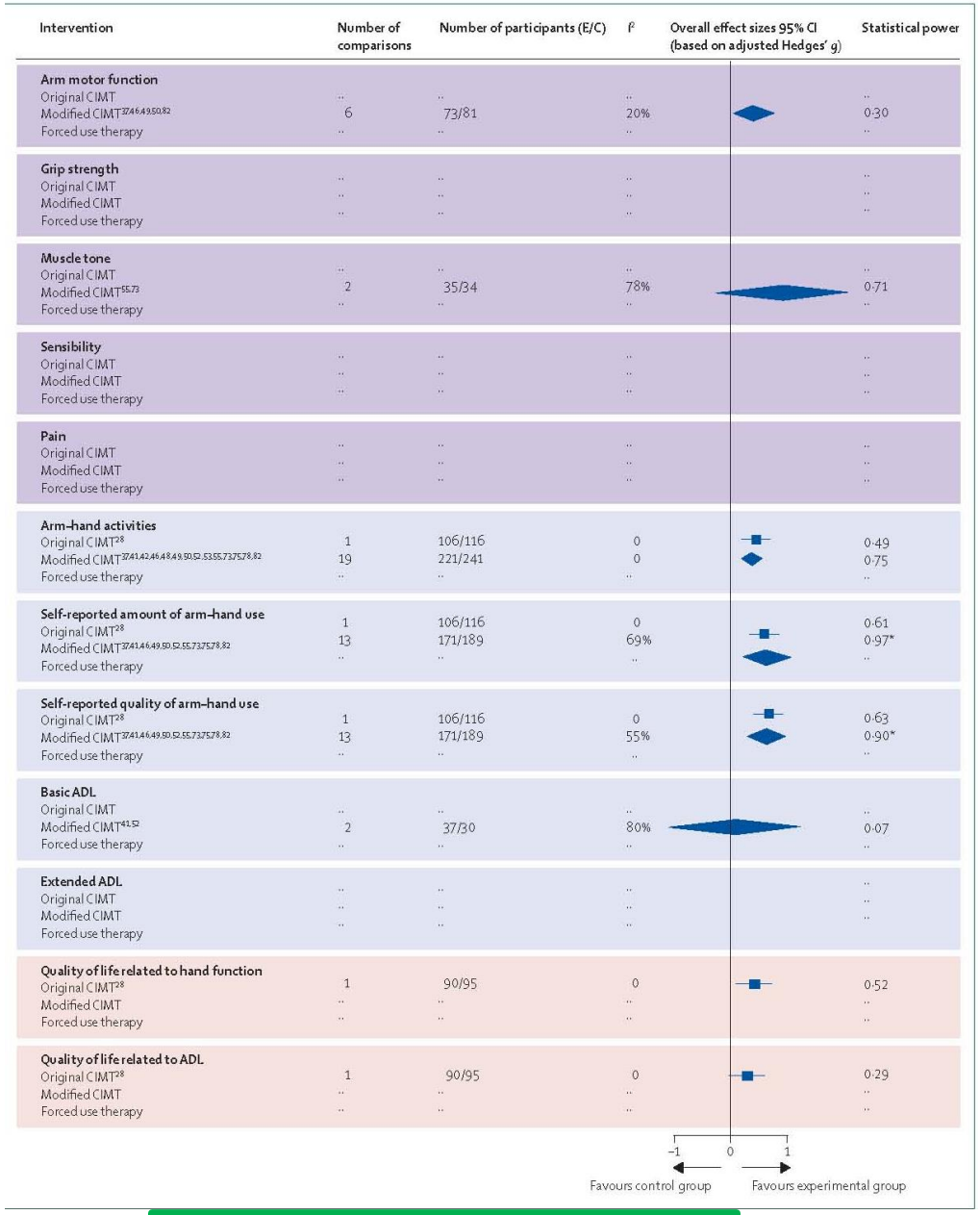


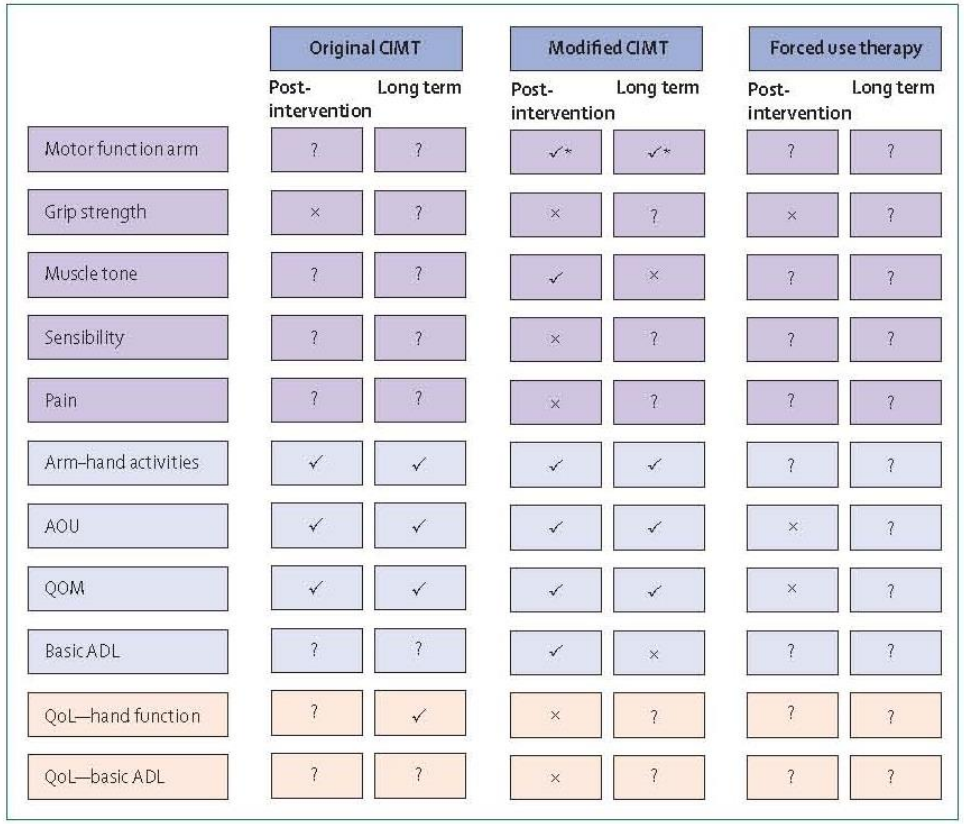
Figure 3: **Forest plot of effects of constraint-induced movement therapy (CIMT), mCIMT, and forced use therapy at long-term follow up**
Classified according to the International Classification of Functioning, Disability, and Health (ICF; WHO). Diamonds represent the overall effect sizes after pooling the standardised mean differences (SMD). The SMD was based on adjusted Hedges' *g* (95% CI) model. If pooling was not possible, the individual SMD is shown based on an adjusted Hedges' *g* analysis. The SMD Hedges' *g* model is a model calculated on the basis of the difference between the means of the experimental and the control group divided by the pooled standard deviation of both groups in a trial and multiplied with a correction factor called J for the degrees of freedom. The appendix shows the calculated Hedges' *g* (95% CI) in numbers. Background colours show the different ICF categories: body functions (purple), activities (blue), and participation (orange). ADL=activities of daily living. E=experimental group. C=control group. ···=no data available. *Sufficient statistical power ($1-\beta \geq 0{\cdot}80$).

Kwakkel et al:
Lancet Neurology,
2015; 14:224-234.



All CIMT vs EXCITE Trial

Kwakkel, Veerbeek van Wegert, Wolf:
Constraint-induced movement therapy after stroke. Lancet (Neurology), 2015, 14:224-234



	Original CIMT		Modified CIMT		Forced use therapy	
	Post-intervention	Long term	Post-intervention	Long term	Post-intervention	Long term
Motor function arm	?	?	✓*	✓*	?	?
Grip strength	×	?	×	?	×	?
Muscle tone	?	?	✓	×	?	?
Sensibility	?	?	×	?	?	?
Pain	?	?	×	?	?	?
Arm–hand activities	✓	✓	✓	✓	?	?
AOU	✓	✓	✓	✓	×	?
QOM	✓	✓	✓	✓	×	?
Basic ADL	?	?	✓	×	?	?
QoL—hand function	?	✓	×	?	?	?
QoL—basic ADL	?	?	×	?	?	?

Figure 4: **Summary of evidence for original constraint-induced movement therapy, modified constraint-induced movement therapy (mCIMT), and forced use therapy**
The evidence for original CIMT, mCIMT, and forced use therapy after intervention and in the long term (4–5 months) is summarised in accordance with the International Classification of Functioning, Disability, and Health model (ICF). Background colours show the different ICF-categories: body functions (purple), activities (blue), and participation (orange). CIMT=constraint-induced movement therapy. ?=unknown effect based on the inability to statistically pool data of randomised controlled trials. ✓=beneficial or likely to be beneficial based on significant positive summary effect sizes. x=uncertain benefit based on non-significant summary effect sizes. AOU=self-reported amount of arm–hand use in daily life. QOM=self-reported quality of arm–hand movement in daily life. ADL=activities of daily living. QoL=quality of life. *Only beneficial or likely to be beneficial within the first 3 months after stroke.

Modified CIMT Unresolved Issues

- Distributed practice patterns vary
- Nature of home training not specified
- Variations in group approach:
  - Japan: in clinic
  - Germany: in home
- Mechanism(s) unexplored including differences compared to signature CIMT
- Direct well controlled comparisons needed

CIMT: A more critical look (n= 612…. 11/18/16)

Shi YX, et al: Modified CIMT versus traditional rehabilitation in patients with upper-extremity dysfunction after stroke: A systematic review and meta-analysis. Arch Phys Med Rehabil. 2011; 92(6) 972-982. (China)

Pollock A, et al: Interventions for improving upper extremity limb function after stroke. Cochrane Database Syst Rev. 2014 Nov 12 (11):CD010820. (Scotland)

Pedlow K et al: Application of CIMT in clinical practice: An online survey. Arch Phys Med Rehabil. 2014; 95:275-282. (Ireland)

Corbetta D et al: COMT for upper extremities in people with stroke. Cochrane Database Syst Rev. 2015 doi:10.1002/14651858.(Italy)

Shi YX, et al: Modified CIMT versus traditional rehabilitation in patients with upper-extremity dysfunction after stroke: A systematic review and meta-analysis. Arch Phys Med Rehabil. 2011; 92(6) 972-982. (China)

- Compare mCIMT to traditional therapy with comprehensive search strategy from English and Chinese literature
- Methodological quality = 5 point scale
- 13 RCT (278 pts; CIMT/TR: 143/135
- CIMT = higher scores (Mean Diff and CI) for ARAT, FMA, MAL, FIM
- Kinematics (mCIMT): shorter Reaction time, >peak velocity but no difference for Normalized MT or total displacement

Kitago T et al: Improvement after CIMT: Recovery of normal motor control or task-specific compensation. Neurorehabilitation and Neural Repair. 2013;27(2):99-109. (USA)

- Demo proof of concept study blending kinematics with clinical outcome measures
- N=10 chronic stroke; mCIMT (2 weeks); ARAT FMA; kinematics of visually guided arm and wrist movements
- ARAT , FMA and kinematics
- Evaluate performance using kinematics????

It’s Really Not About the Mitt!!!

Advanced Technologies for Stroke Rehabilitation in the Home

Impending Factors/Influences:

- Patient compliance
- Caregiver interest and commitment
- Realistic expectations
  - The “”Pharma” Conundrum
- Socio-economic and cultural considerations
- Home preparedness
- Costs and reimbursement

Summary Points: “The Take Home”

- Constraint-Induced Movement Therapy (CIMT) has met with favorable success in select stroke survivors
- Elements of CIMT formed part of the foundation for elements within the ICARE Clinical Trial
- Emphasizes on unimanual training must be balanced against the reality of bimanual function
- Concepts embedded with the Accelerated Skill Acquisition Program (ASAP) expand the concept of “physical” therapy to embrace multiple behaviors
- “Reaching” a common end point across interventions for those who have movement out of synergy

Thank You

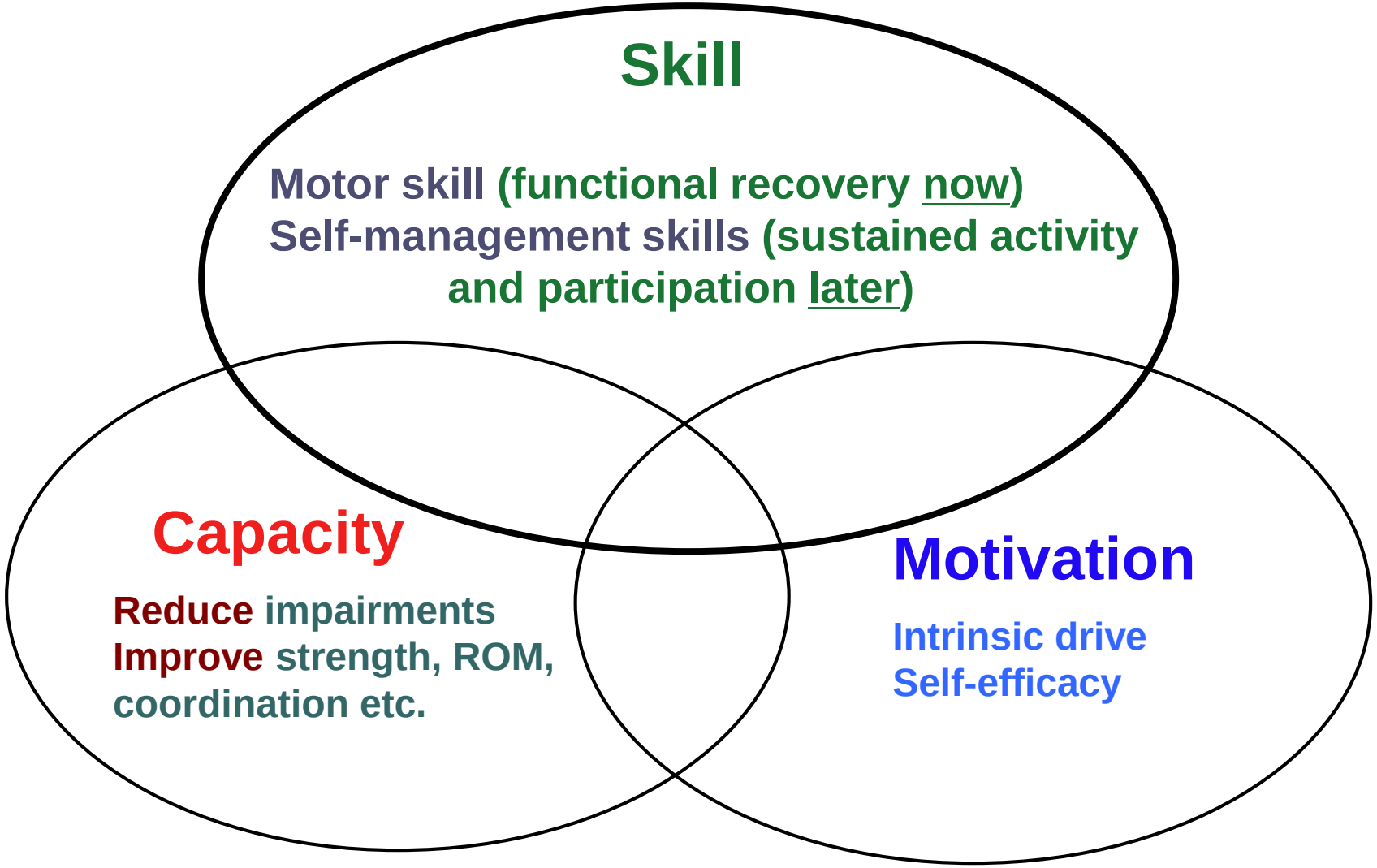
The I-CARE (Interdisciplinary Comprehensive Arm Rehabilitation Evaluation) for Stroke Initiative Trial NS 056256 (8/08 – 7/14)

Carolee J. Winstein, Ph.D., FAPTA (PI)

Alex Dromerick, MD (co-PI)

Steven L. Wolf (co-PI)

Key Elements for Accelerated Skill Acquisition Program



Assumptions of “Accelerated Skill Acquisition Program” (ASAP)

- Effective rehabilitation of the hemiparetic arm and hand is achievable and

based upon:

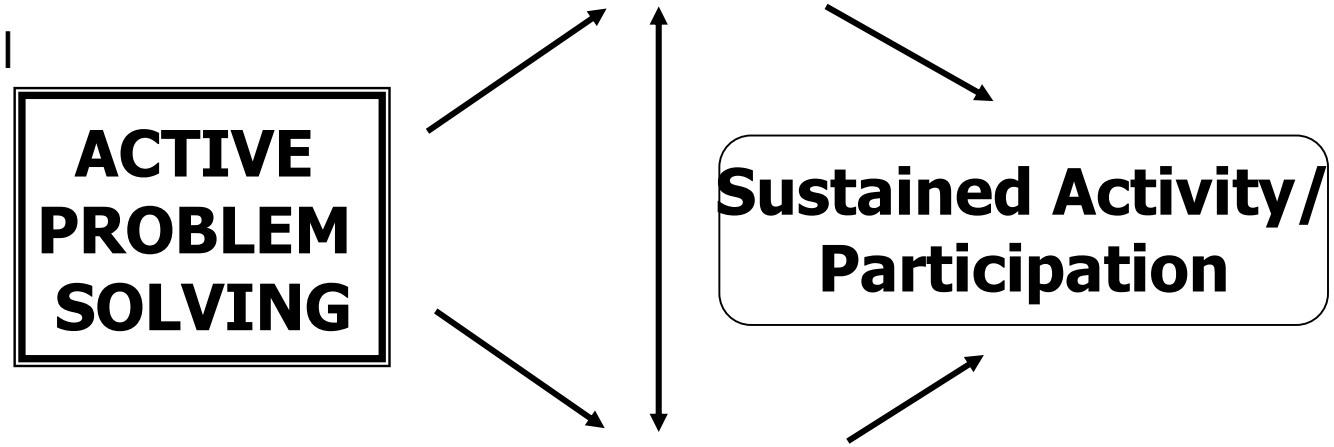
- provision of challenging, intensive, and meaningful practice for skill acquisition,
- mitigation (reduction) of “linchpin” impairments and dysfunctions of movement, and
- confidence to integrate use of emerging skills and motor capacities into everyday life

Accelerated Skill Acquisition Program (ASAP)

THEORY **INTERVENTION** **OUTCOMES**

Motor Learning Capacity:
Information Processing, implicit and explicit learning; Neural correlates of skill learning

Skill Acquisition
(Retention, Transfer, Consolidation
Motor skill representation)



Motivation:
Social-cognitive (e.g., Self-efficacy, self-determination)

Behavior
(Choice, Effort, Persistence, Self-management)

Interdisciplinary model including social, cognitive and neuroscience domains

Important Considerations

Impending Factors/Influences:

- Patient compliance
- Caregiver interest and commitment
- Realistic expectations
  - The “”Pharma” Conundrum
- Socio-economic and cultural considerations
- Home preparedness
- Costs and reimbursement

Winstein CJ et al: JAMA, 2016, 315(6), 571-581

Research

Original Investigation

Effect of a Task-Oriented Rehabilitation Program on Upper Extremity Recovery Following Motor Stroke The ICARE Randomized Clinical Trial

Carolee J. Winstein, PhD; Steven L. Wolf, PhD; Alexander W. Dromerick, MD; Christianne J. Lane, PhD; Monica A. Nelsen, DPT; Rebecca Lewthwaite, PhD; Steven Yong Cen, PhD; Stanley P. Azen, PhD; for the Interdisciplinary Comprehensive Arm Rehabilitation Evaluation (ICARE) Investigative Team

IMPORTANCE Clinical trials suggest that higher doses of task-oriented training are superior to current clinical practice for patients with stroke with upper extremity motor deficits.

OBJECTIVE To compare the efficacy of a structured, task-oriented motor training program vs usual and customary occupational therapy (UCC) during stroke rehabilitation.

Supplemental content at jama.com

Winstein CJ et al: JAMA, 2016, 315(6), 571-5

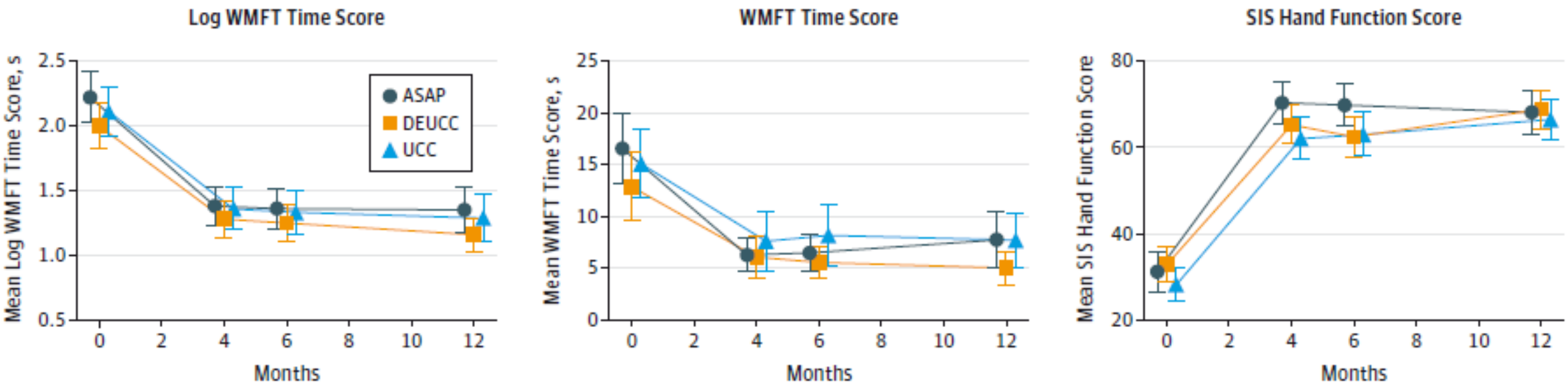
DESIGN, SETTING, AND PARTICIPANTS Phase 3, pragmatic, single-blind randomized trial among 361 participants with moderate motor impairment recruited from 7 US hospitals over 44 months, treated in the outpatient setting from June 2009 to March 2014.

INTERVENTIONS Structured, task-oriented upper extremity training (Accelerated Skill Acquisition Program [ASAP]; n = 119); dose-equivalent occupational therapy (DEUCC; n = 120); or monitoring-only occupational therapy (UCC; n = 122). The DEUCC group was prescribed 30 one-hour sessions over 10 weeks; the UCC group was only monitored, without specification of dose.

MAIN OUTCOMES AND MEASURES The primary outcome was 12-month change in log-transformed Wolf Motor Function Test time score (WMFT, consisting of a mean of 15 timed arm movements and hand dexterity tasks). Secondary outcomes were change in WMFT time score (minimal clinically important difference [MCID] = 19 seconds) and proportion of patients improving ≥ 25 points on the Stroke Impact Scale (SIS) hand function score (MCID = 17.8 points).

Winstein CJ et al: JAMA, 2016, 315(6), 571-5

Figure 2. Longitudinal Changes in Unadjusted Imputed Mean Scores Across Months for the Primary and Secondary Outcomes



Thoughts and Future Projections

- ❑ Does “one size fit” all?
- ❑ A hard look at the evidence…who qualifies for which interventions?
- ❑ Is treatment a “moving target”? How “new” is ASAP?
- ❑ Is all “therapy” physical or occupational?
- ❑ A changing culture with high tech expectations?
- ❑ How will “one-on-one” interventions be defined?
- ❑ Will sensing technology and gaming replace the clinician?
- ❑ Facing reality…. who can we treat effectively?
- ❑ Can we afford to see things as we want them? …..the compassion – reality conundrum.