

# Effect of intensity on rehabilitation outcomes: What's the evidence? (Version with most patient-pictures removed)

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# Learning objectives

The learner will be able to:

Define “intensity” in the context of rehabilitation practice

Describe appropriate treatment intensity to improve outcomes for

1. Upper extremity function
2. Mobility function
3. Neural plasticity
4. Physical activity and aerobic capacity;

Discuss strategies to measure and increase physical rehabilitation intensity in current practice



# Outline

1. What is the current intensity of rehabilitation practice?
2. What intensity is required for meaningful improvement (based on published interventions)?
3. What strategies can be used to increase intensity to effective levels in today's rehabilitation setting?

Individual studies rarely by themselves provide sufficient evidence for practice changes.

1/3 of initial studies were contradicted or less effective

[JAMA. 2005;294:218-28](#)

## Contradicted and Initially Stronger Effects in Highly Cited Clinical Research

John P. A. Ioannidis, MD

**C**LINICAL RESEARCH ON IMPORTANT questions about the efficacy of medical interventions is sometimes followed by subsequent studies that either reach opposite conclusions or suggest that the original claims were too strong. Such disagreements may upset clinical practice and acquire publicity in both scientific circles and in the lay press. Several empirical investigations have tried to address whether specific types of studies are

**Context** Controversy and uncertainty ensue when the results of clinical research on the effectiveness of interventions are subsequently contradicted. Controversies are most prominent when high-impact research is involved.

**Objectives** To understand how frequently highly cited studies are contradicted or find effects that are stronger than in other similar studies and to discern whether specific characteristics are associated with such refutation over time.

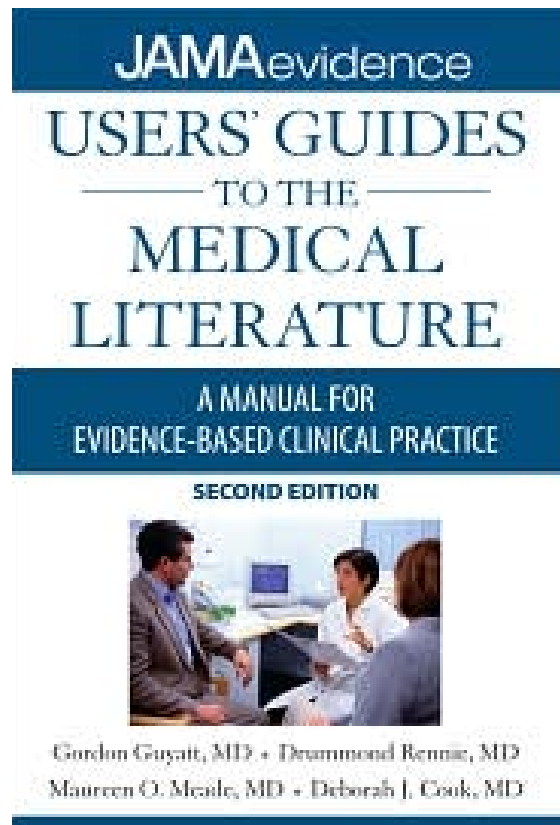
**Design** All original clinical research studies published in 3 major general clinical journals or high-impact-factor specialty journals in 1990-2003 and cited more than 1000 times in the literature were examined.

**Main Outcome Measure** The results of highly cited articles were compared against subsequent studies of comparable or larger sample size and similar or better controlled designs. The same analysis was also performed comparatively for matched studies that were not so highly cited.

**Results** Of 49 highly cited original clinical research studies, 45 claimed that the inter-

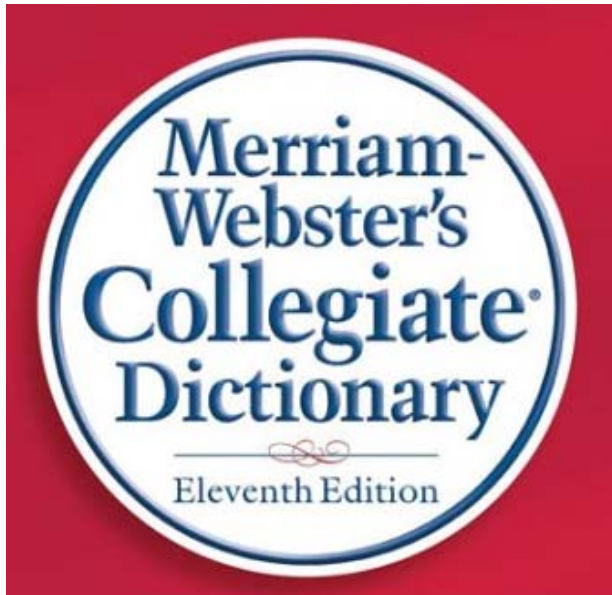
“We now recommend that resolving a clinical problem begins with a search for a valid systematic review or practice guideline as the most efficient method of deciding on the best patient care.”

Guyatt and Rennie (1994). *JAMA*.



# Definition of Intensity

in·ten·si·ty **noun** \in-ˈtɛn(t)-sə-tē\



Magnitude of quantity (e.g., force, energy)  
unit (e.g., time)

Amount  
Time

Dose : measured quantity of a therapeutic agent taken at one time



# Rehabilitation Definition of Intensity

120 minutes therapy  
week

50% heart rate reserve  
20 minutes

60 movement reps  
session

1000 steps  
day

Increasing the top number elevates the intensity, but does not necessarily guarantee to be more effective  
.... In some cases, could be detrimental.

We need to know the evidence of what intensity or dose is effective.

# Neuroplasticity

**Adaptive changes in the structure or function of nerve cells in response to injuries, development, use or disuse.**

## **Neurogenesis**

**– generation of new neurons**

## **Synaptogenesis**

**– formation of new synapses or remodeling of existing synapses**



# Can we grow new brain cells (neurogenesis)?

Mice who did voluntary running (running wheel) grew an average of 6,000 new brain cells per cubic millimeter in the hippocampus (double over controls).

Creer et al. (2010)



# Can we grow bigger neurons in the brain?

“The adult brain has been considered relatively hard-wired and limited in its capacity for structural change. Here we show the first unambiguous evidence of dendrite growth and remodeling in adult neurons. Over a period of months, neurons could be seen extending and retracting existing branches, and in rare cases adding new branch tip. These findings have important implications for models of cortical functional circuitry and its activity-dependent modulation.” Lee et al. 2006



# Stroke induces formation of new neurons

“The magnitude of striatal neurogenesis after stroke is similar in young and old animals, indicating that this potential mechanism for self-repair also operates in the aged brain.” Darsalia et al. 2005

# What intensity is effective after stroke?



**“My doctor told me to double my exercise program, so I switched from NOT exercising three times a week to NOT exercising six times a week.”**

# Upper Extremity Function



## How many upper extremity reps can positively change the brain?

Following a stroke lesion to the motor cortex of monkeys, neural plasticity has been induced with 900 reach and grasp repetitions per day

- Dendritic growth in cortex
- Hand representation within primary motor cortex was regained



## Use of the arm relates to brain recovery

Less you use the paretic arm, the more the unaffected hemisphere activates

*Greater activation of secondary motor areas is related to less arm use after stroke. Kokotilo, Eng, Boyd et al. Neurorehab Neural Repair 2009*



## How many upper extremity reps are being done?

7 sites (including GF Strong Rehab Centre in Vancouver)

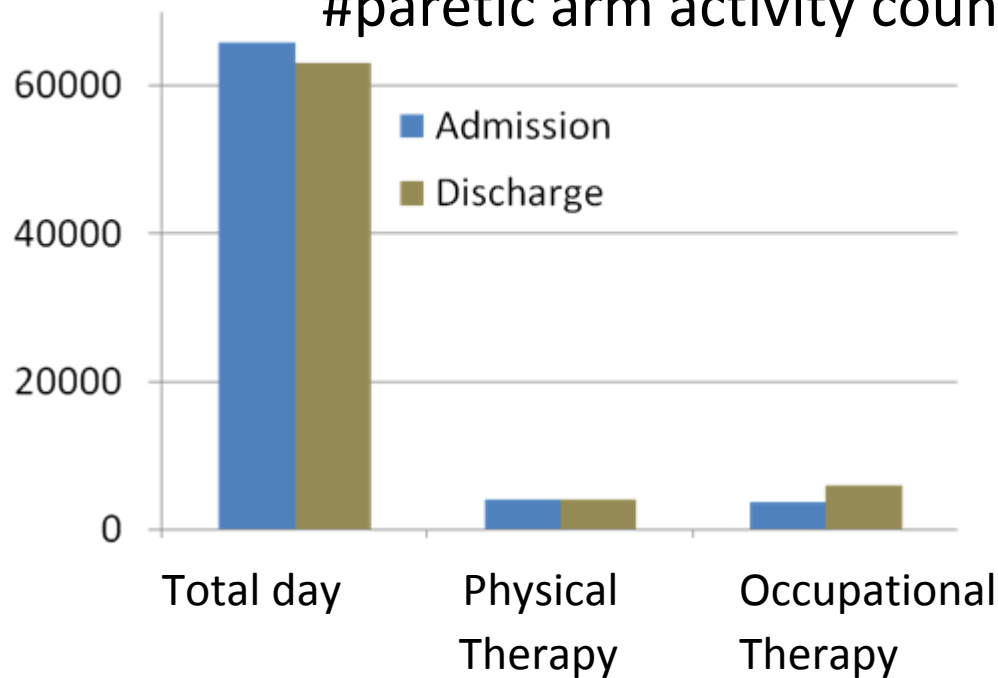
41 upper extremity functional repetitions/OT session

12 upper extremity functional repetitions/PT session

Lang et al. 2009

# Arm activity is low in stroke rehab

#paretic arm activity counts



Rand, Eng et al. 2010

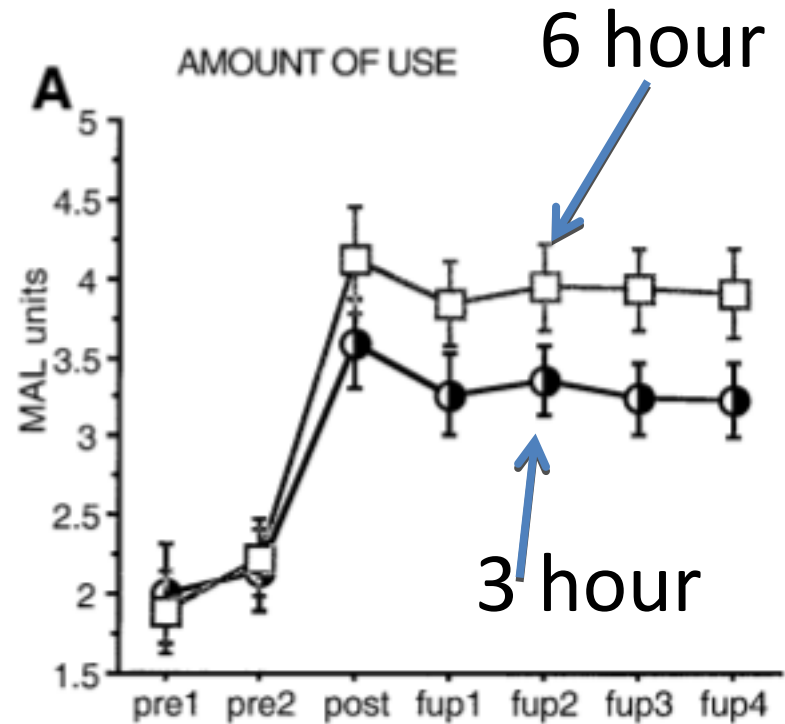
Age-matched controls have 180,000 counts (3 times as much)

## Constraint-induced movement therapy

- Meta-analyses demonstrate effectiveness for conventional protocol (6 hour therapy + constraint for 90% waking hours over 2 weeks)
  - Use of arm improved
  - 24-48 months benefits
  - Increased representation of paretic hand in cortex

6 hour protocol has better outcomes than 3 hour protocol

Sterr et al. 2002



Greater intensity leads to better outcomes



## Are the effects due to the constraint or therapy?

3 hour constraint protocol + mitt versus 3 hour constraint protocol alone over 2 weeks

*Brogardh et al. 2009; 2010*

Addition of mitt has no beneficial effects over a 3 hour training/day for 2 weeks.

Effects appear to be due to therapy.



# Does earlier treatment result in better outcomes?

## ■ VECTOR trial

Dromerick et al. 2009

- 10 days post acute stroke
- 3 hour constraint group did worse
- 2 hour constraint group did equally well as 2 hour conventional OT

## ■ EXCITE trial

Wolf et al. 2008;2010

- Early (3-9 months) vs late (15-21 months)
- Early had advantages at 12 months, but similar changes at 24 months



## Does earlier treatment result in better outcomes?

Too much intensity in acute phase may be detrimental  
Early intensity may have advantages in sub-acute period



## Can robotics help increase intensity?

- Patients > 6 months post-stroke *Lo et al. 2010*
  - 3 month robot-assisted program, 3X/week
  - 1024 movements per session on average
  - Therapy-assisted comparison group

Intensity is key, modality does not make a difference



## Strategies to increase upper extremity intensity in your practice

- Functional electrical stimulation
- Upper extremity group / Circuit Programs
- Use of non-therapy time
- Use of caregivers
- Ensure intensity monitoring of standard therapy

- Level 1 evidence that FES improves upper extremity function in sub-acute and chronic stroke Foley et al. 2009





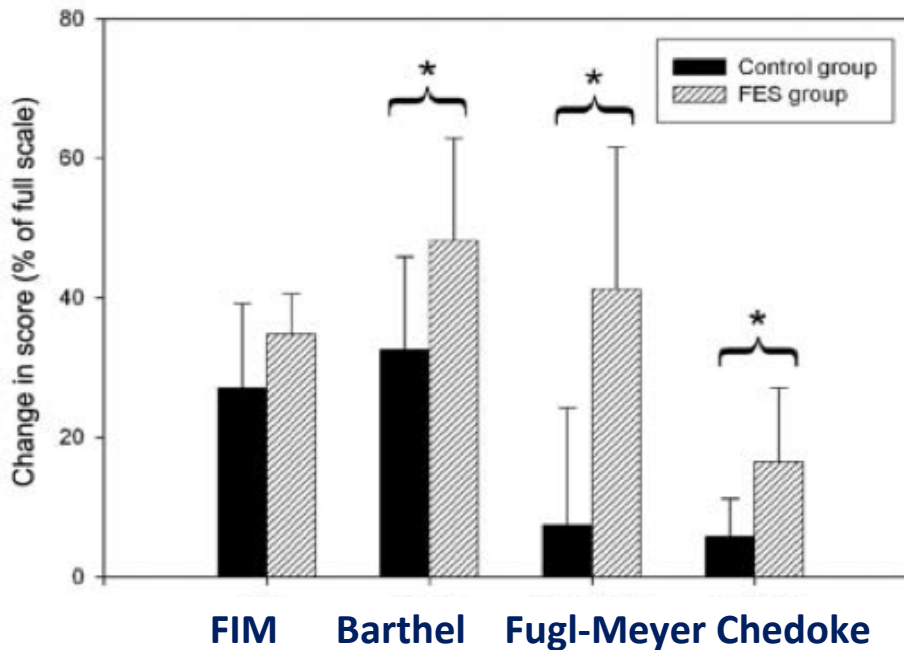
# How can you increase intensity for severe stroke?

- Severe stroke
  - Spastic or flaccid paralysis of arm and hand
  - Little or no voluntary movement
  - Standard care of 45 min PT and OT vs FES integrated into regular PT/OT (matched time)
  - 3-4 months treatment

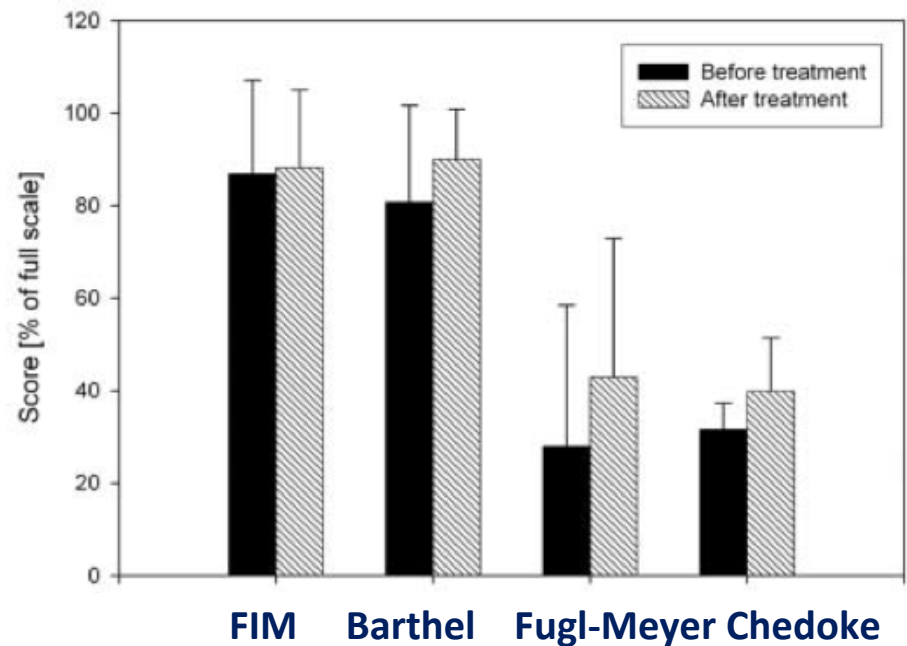
Thrasher et al. 2008

# FES has positive outcomes in severe stroke in sub-acute

**Acute Stroke (within 4 weeks)**



**Chronic Stroke (mean 3 years)**



**Thrasher et al. 2008**

Intensity can be increased with FES and lead to better outcomes  
 The modality makes a difference.  
 Earlier application has better outcomes.

## **GRASP Graded repetitive arm supplementary program**

- Patients admitted to inpatient rehabilitation not more than 4 weeks since stroke
- 4 week self-directed arm and hand homework program
- 4 stroke rehabilitation hospitals
- Exercise book and kit
- Log sheet to track exercises - target 1 hr/day (actual 40 min)
- Control group received educational program

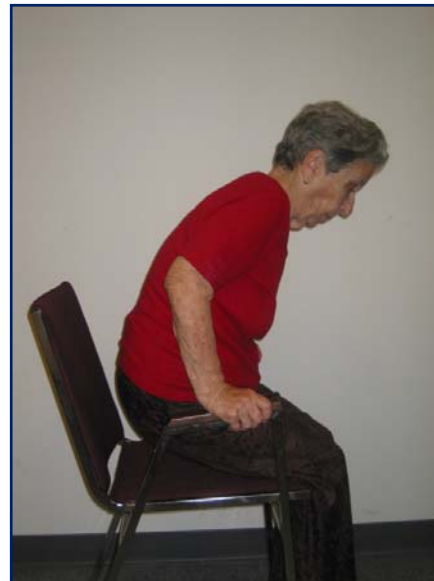
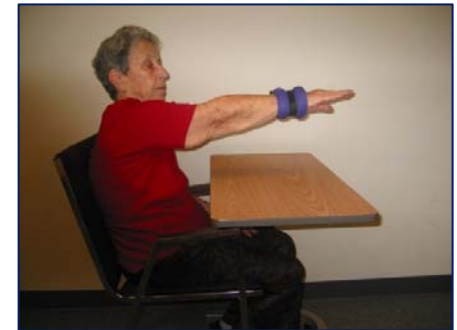
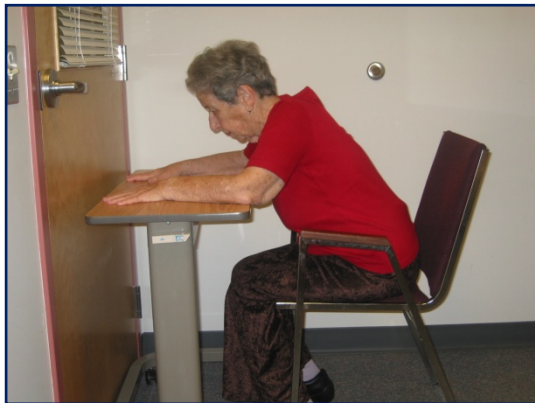
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[www.rehab.ubc.ca/teng](http://www.rehab.ubc.ca/teng)

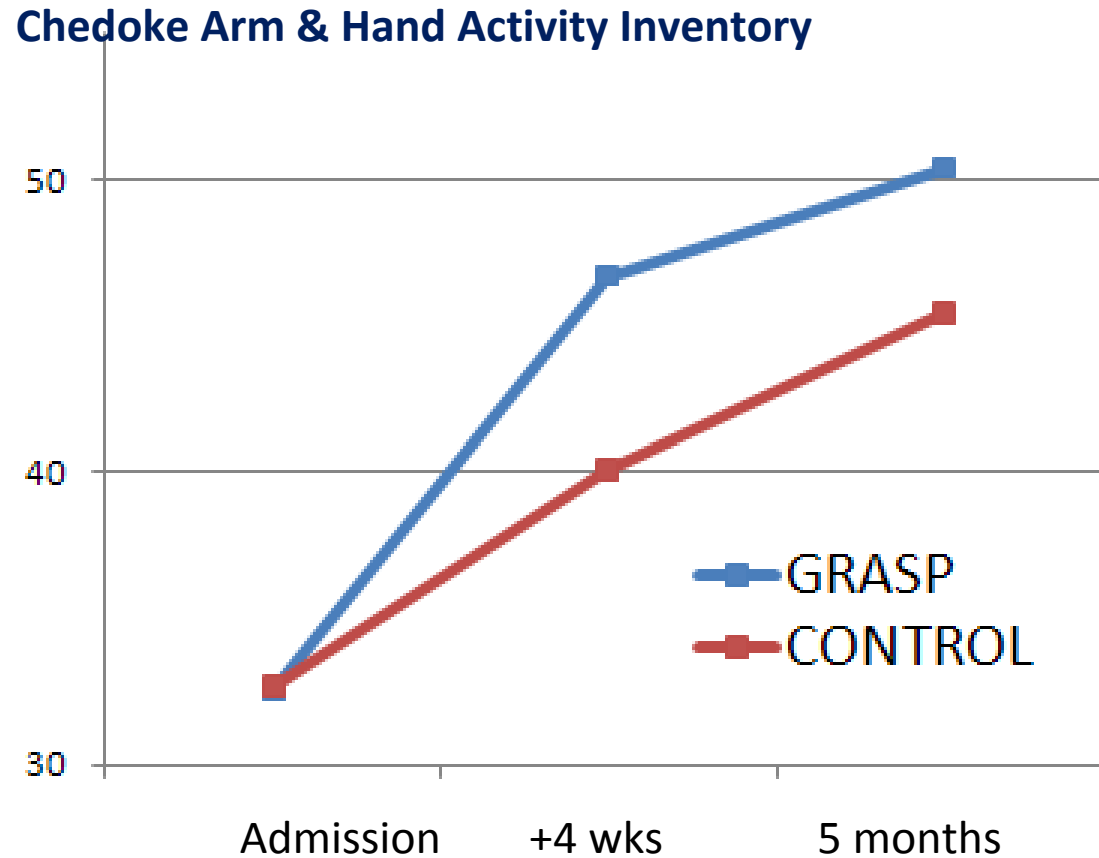
*A self-administered Graded Repetitive Arm Supplementary Program improves arm function during inpatient stroke rehabilitation: A multi-site RCT. Harris, Eng et al. Stroke 2009*

# GRASP Graded repetitive arm supplementary program

- Range of motion exercises
- Strengthening exercises
- Weight-bearing exercises
- Functional tasks
- Fine motor skills



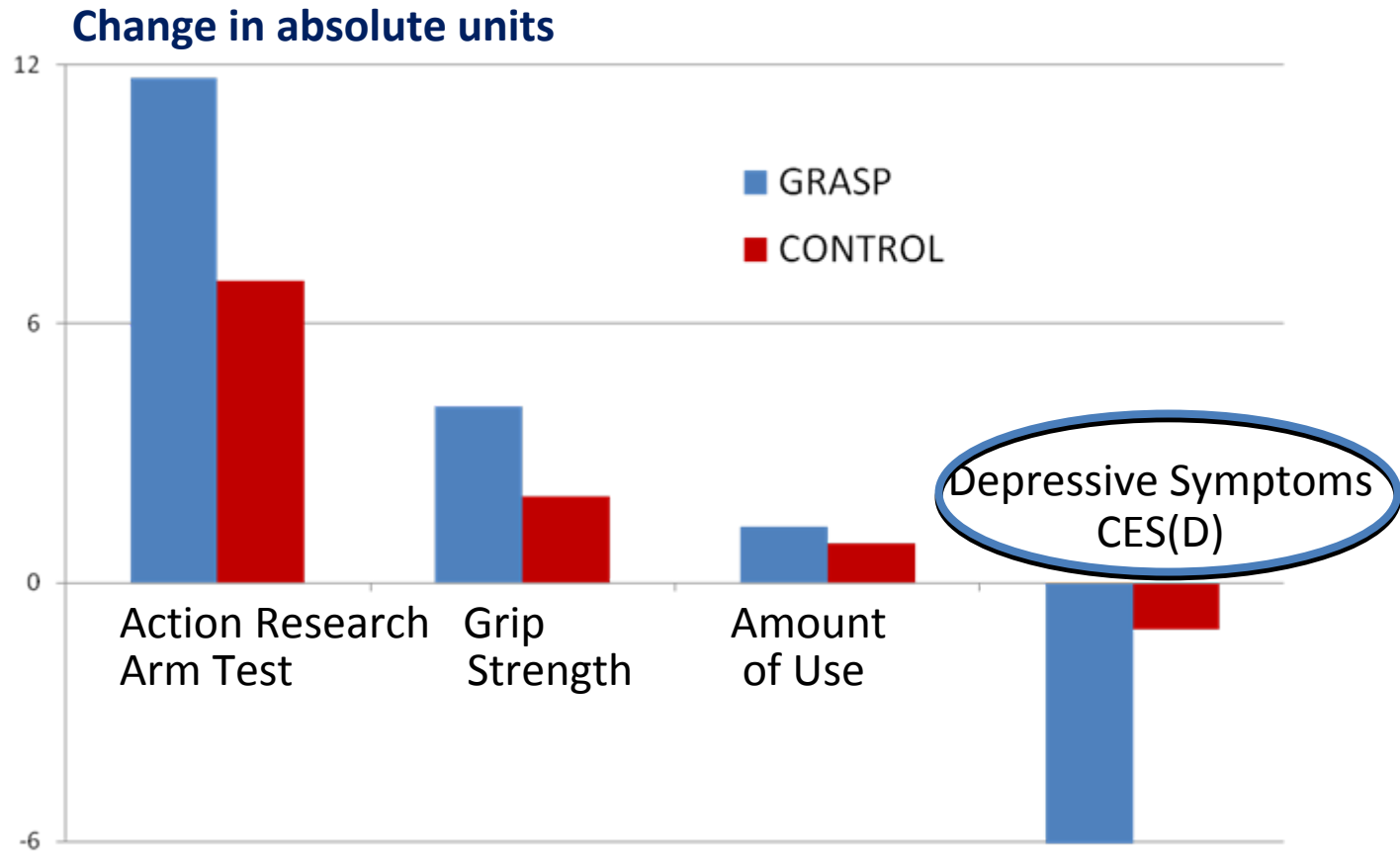
# GRASP improved arm and hand function



Tasks include taking lid off a jar, doing up buttons, putting toothpaste on a toothbrush



# GRASP improved grip strength & use of the hand GRASP reduced depressive symptoms



- GRASP is an inexpensive method to improve upper limb function
- Safe and effective, & promotes upper limb use outside of therapy time
- GRASP participants had less depressive symptoms
- Foster self-management of therapy and inclusion of family
- Currently used in Canada, US, France, Australia, UK, China, Sweden, Greece.....



## Caregiver support and GRASP

- Those who had caregiver assistance with GRASP had better outcomes (regardless of starting impairment)
- Those with caregiver assistance did more hours of GRASP

Caregivers can assist in increasing the therapeutic intensity of treatments



## Group programs to increase intensity

- 1 hour, 3X/week, 5 months
- Community-living with stroke
- Group program
- > 50 years, mean 70 years
- Fugl-Meyer: range from 10-52

*A community-based group upper extremity exercise program improves motor function and functional activities in chronic stroke: an RCT. Pang, Eng et al. Arch Phys Med Rehabil 2006*

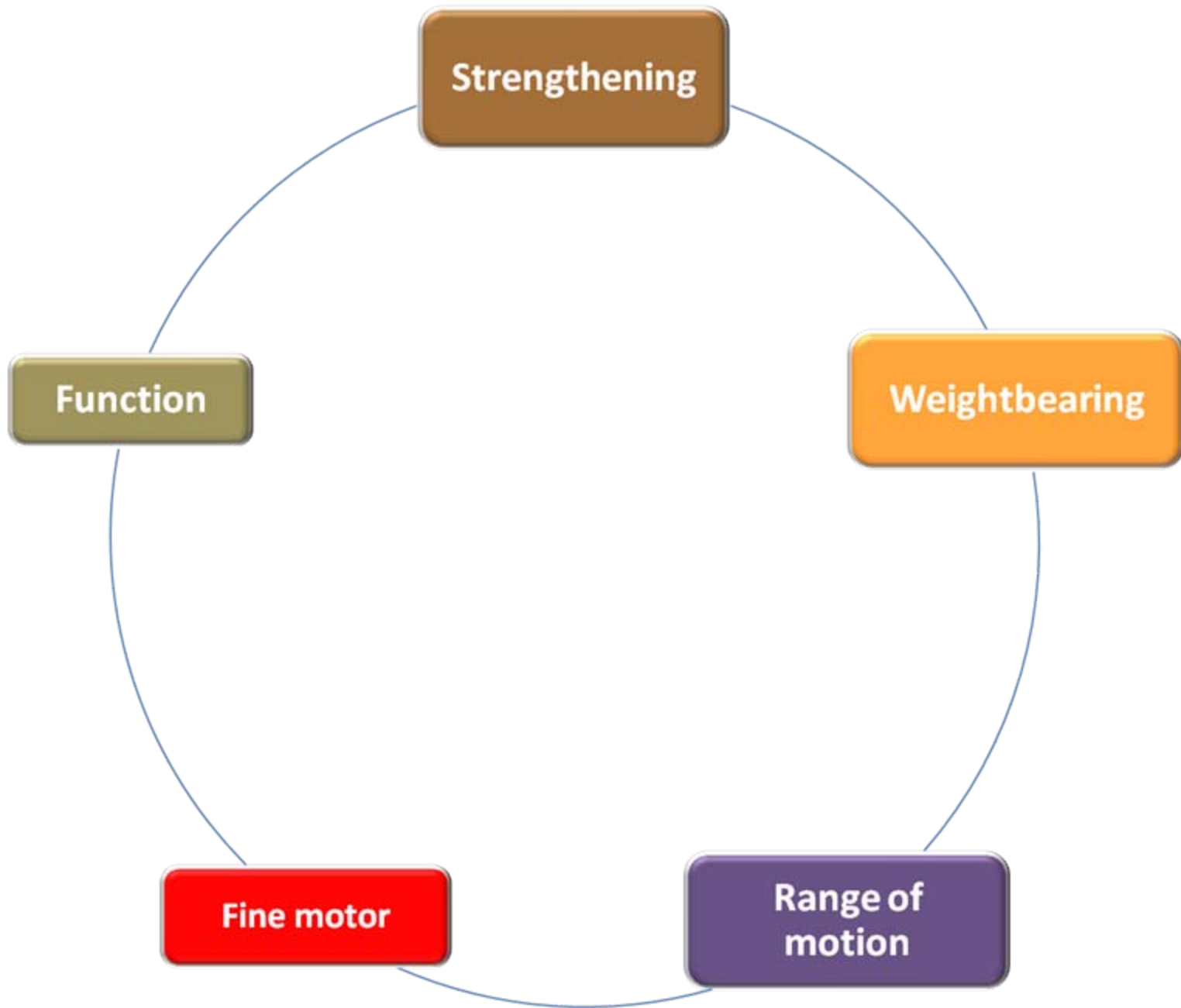
**Strengthening**

**Function**

**Weightbearing**

**Fine motor**

**Range of motion**





# Comparison with Excite

- Arm use (Motor Activity Log):
  - 1.0 for mild, 0.5 for mod. severity (Excite 1.0)
- Grip strength:
  - 16% improvement (Excite 25%)
- Wolf Motor Function Test:
  - 0.3 for mild; 0.4 for moderate (Excite 0.3)

# Grading the exercise prescription



“My doctor told me to start my exercise program very gradually. Today I drove past a store that sells sweat pants.”



# Maximizing activation, minimizing fatigue

- May need to vary task so muscle fatigue does not limit aerobic workout
- Monitoring intensity
  - Keep task challenging
  - #reps
  - Amount of minutes



# Exertion fatigue versus chronic fatigue

- Exertion fatigue related to aerobic conditioning
- Chronic fatigue related to depression
- Monitoring and educating about fatigue

*Tseng et al. 2010*



# Increasing intensity of upper extremity practice

- Functional exercises for grip (10 min), hand manipulation (10 min), finger control (10 min) – clock stops when resting!
- Ratings of perceived exertion: somewhat hard to hard
- Intensity increased by manipulating:
  - Support by therapist
  - Change in speed, but maintaining accuracy
  - Change in object characteristics
    - Weight, shape, size, friction
- #Reps
- Amplitude and Range
  - Predictability

***Wallace et al. 2010***



# Increasing intensity of upper extremity practice

- Strengthening at 3 sets of 10 at 60-80% max (30 min)
  - Wrist extension, finger extension, grip, thumb abduction
  - Grade 1 – active assisted
  - Grade 2 – eccentrically in range outside of active concentric control
- Ratings of perceived exertion (hard to very hard)

*Wallace et al. 2010*



# Key issues of upper extremity intensity

- Intensity is currently low
- Intensity can be increased with
  - Monitoring of reps/time/exertion
  - Group programs
  - Circuit programs
  - Patient-directed programs
  - Caregiver involvement

# Mobility Function



# How many steps are required to change the brain?

30 minutes treadmill running in rats after a stroke increased synaptophysin (protein involved in synaptic transmission) of subcortical regions of brain

(> 4000 steps/session)

Seo et al. 2010



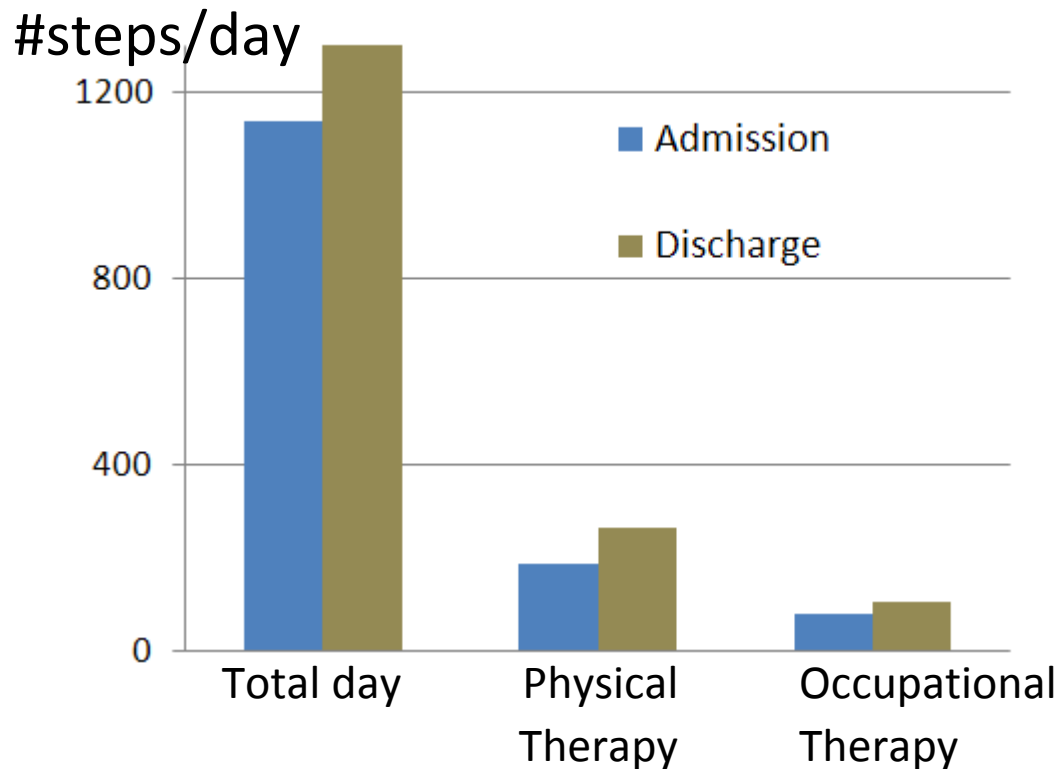
## How many steps are being done?

7 sites (including GF Strong  
Rehab Centre in Vancouver)

121 walking steps/OT session  
370 walking steps/PT session

Lang et al. 2009

# Walking activity is low in stroke rehab



- Minimum 5000 steps/day required for people living in the community
- 6 minute Walk Test will generate 500 steps if you walk slowly

*Physical activity after stroke: are these individuals walking enough during their first year post-stroke? Rand D, Eng JJ.*



# Gait training – what modality is best?

Overground training versus body-weight support treadmill training produce similar outcomes at matched intensities

**Fancheschini et al. 2009**

**Eng and Tang, 2007**

**Moseley et al. 2005**

However, mechanical assistance (body-weight support) may produce better outcomes for non-ambulatory patients compared to overground early after stroke.

**Ada et al. 2010**



# Gait training – how much is best?

16 hours of additional exercise therapy improved walking outcomes (Kwakkel et al. 2004)

Additional 30-60 min daily of gait/circuit training during inpatient rehab (3-5X/day)(Eng and Tang, 2007) - 1800 steps



## What are strategies to increase mobility intensity in your practice?

- Early mobility group
- Use of non-therapy time
- Group programs
- Ensure intensity monitoring of standard therapy



# Adding intensity early after stroke

## AVERT trial

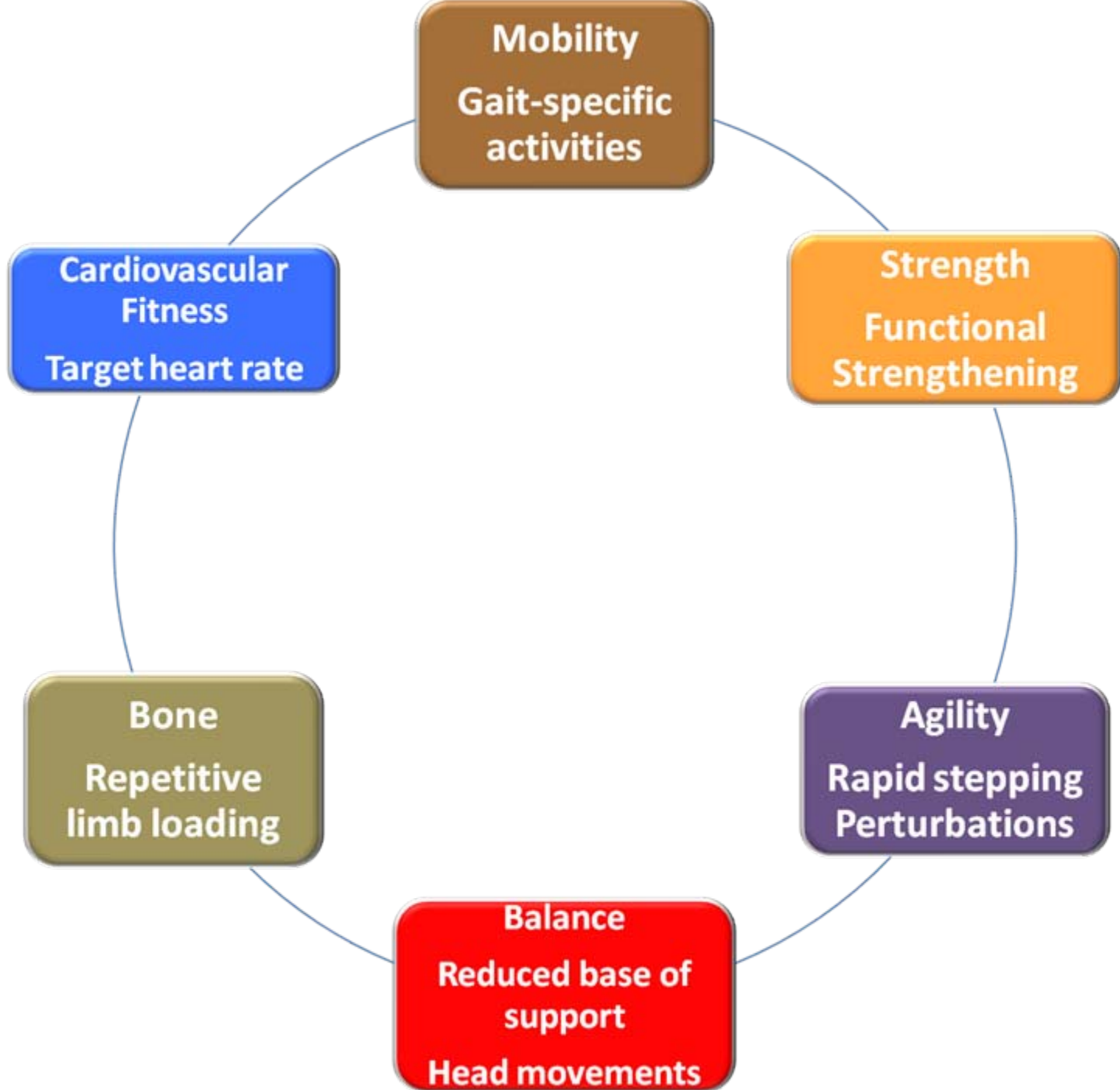
- Mobilize within 24 hours of stroke, then daily for 14 days or discharge
- Delivered by a nurse/physiotherapist
- Assist the patient to be upright and out of bed (sitting or standing as able) at least twice per day; in addition to their usual care, 6 days per week.
- This was expected to double the dose previously
- Mobilization included the use of hoists, where necessary



[www.rehab.ubc.ca/jeng](http://www.rehab.ubc.ca/jeng)

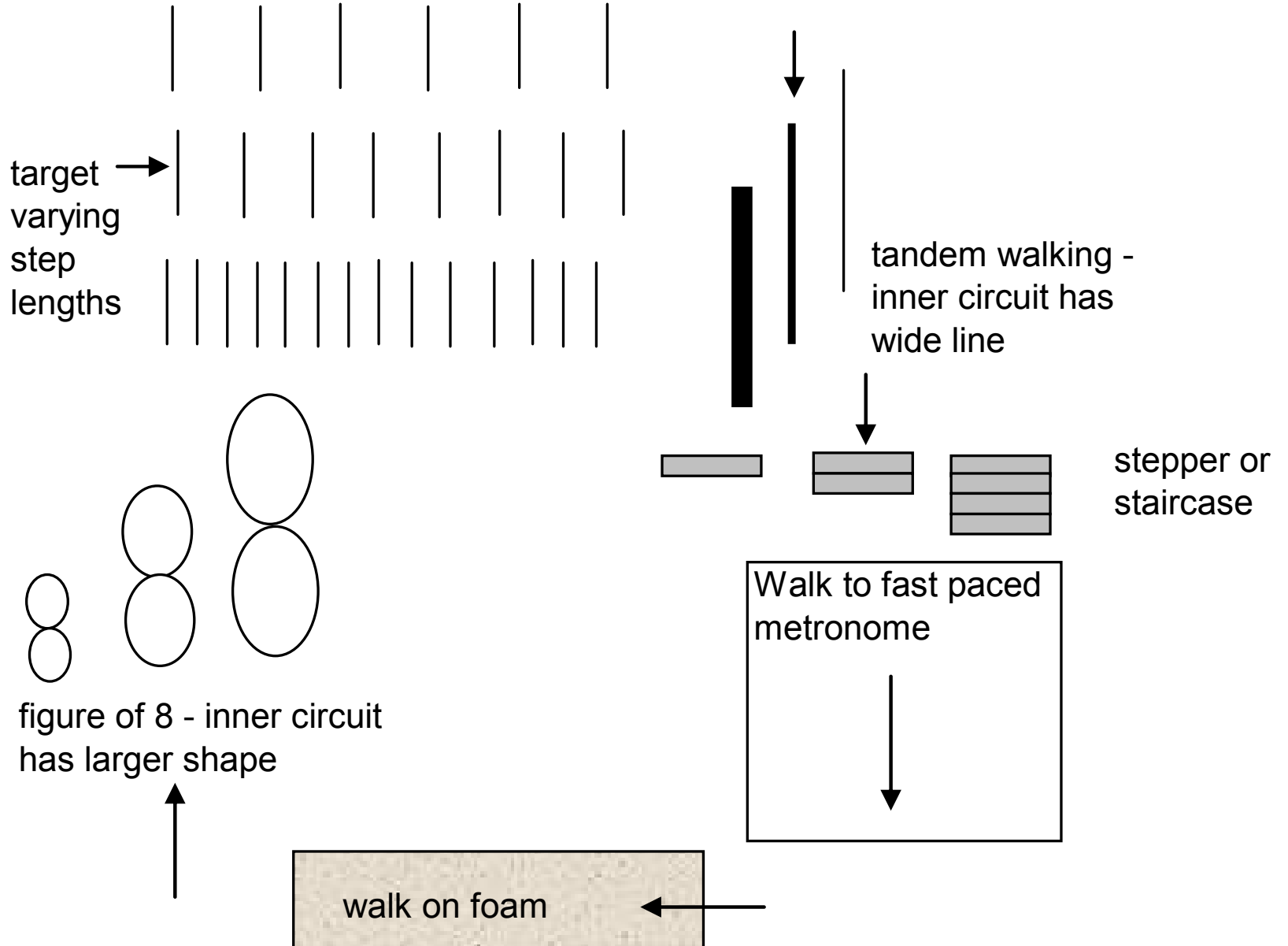
- Community-based group program
- 60 min, 3X/week, minimum 10 weeks
- 3:1 to 5:1 (participant: instructor)

- *A community-based group exercise program for stroke. Eng, Chu et al. Med Sci Sports Exer 2003.*
- *A community-based fitness and mobility exercise program for stroke: An RCT. Pang, Eng et al. JAGS. 2005.*
- *Exercise leads to faster postural reflexes, improved balance and fewer falls in stroke. Marigold, Eng et al. JAGS. 2005.*
- *A 6 month exercise and recreation program to improve executive functioning and memory in stroke. Rand, Eng, Liu-Ambrose et al. 2010.*



# Fitness and Mobility Exercise (FAME)

# Balance circuit





# Improvements from FAME

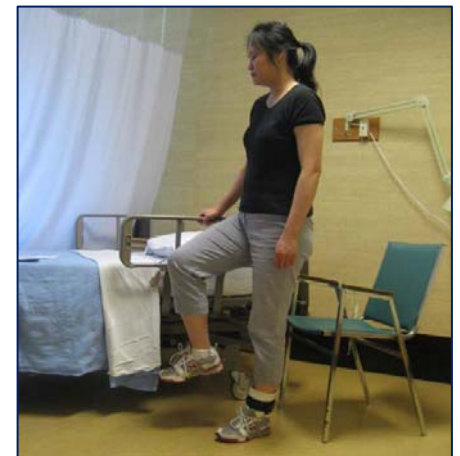
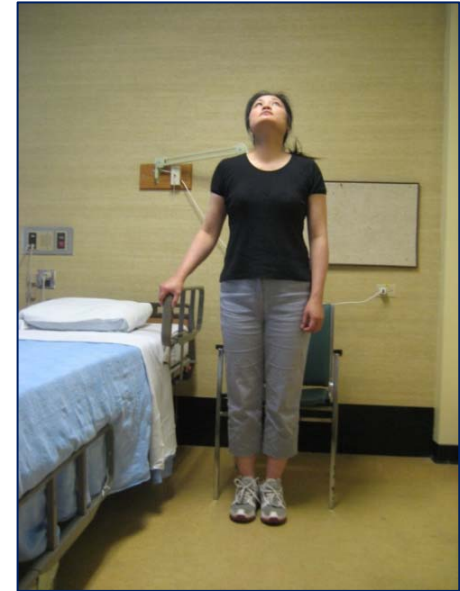
Variable	Change
Balance	2-5 points Berg Balance Scale
Postural reflex	25 ms faster
Falls (12 months)	1.5X more falls in controls
Walking distance	25% further (6 Minute Walk Test)
Balance confidence	6-10 points (Activities-specific Balance Confidence)
Cardiovascular fitness	10% oxygen consumption (VO <sub>2</sub> max)
Muscle strength	20-25% stronger
Hip bone density	Maintenance vs 3% bone loss in controls
Quality of life	Both groups improve



## Group Fitness and Mobility Exercise

- Can increase physical activity, improve use of the leg, and improve walking
- Can reduce the risk of secondary complications like falls, fractures, heart disease and osteoporosis
- Currently in use in Canada, US, Australia, Taipei, Hong Kong, Iceland...
- Currently used with stroke, multiple sclerosis, Parkinson's disease and frail older adults

## SPIRAL Supplementary program in repetitive activity of the leg



# Pedometers to monitor activity and set targets



New Life 2000  
 Accumeasure SL 330  
 Yamax SW 200

All pedometer underestimate steps for slow gait speeds (<0.7 m/sec)



# Key issues in increasing intensity for mobility

- May need to vary task so muscle fatigue does not limit activity
- Monitoring intensity
  - Keep muscle activity challenging
    - Eg, riser under feet for sit to stand
  - Balance activity does not need to be at the point of balance loss
  - #reps, minutes, #steps, RPE
  - Time out of bed/time on feet
- Rehab environment

# Physical activity and cardiovascular health



**“Today is the day that I am going to think about thinking about joining the gym.”**

A light gray map of Canada is shown in the background, with the provinces and territories outlined. The map is centered on the continent.

## Canadian Community Health Survey

- 25,000 seniors with chronic conditions
- 1200 seniors with stroke (5%)



Statistics Canada

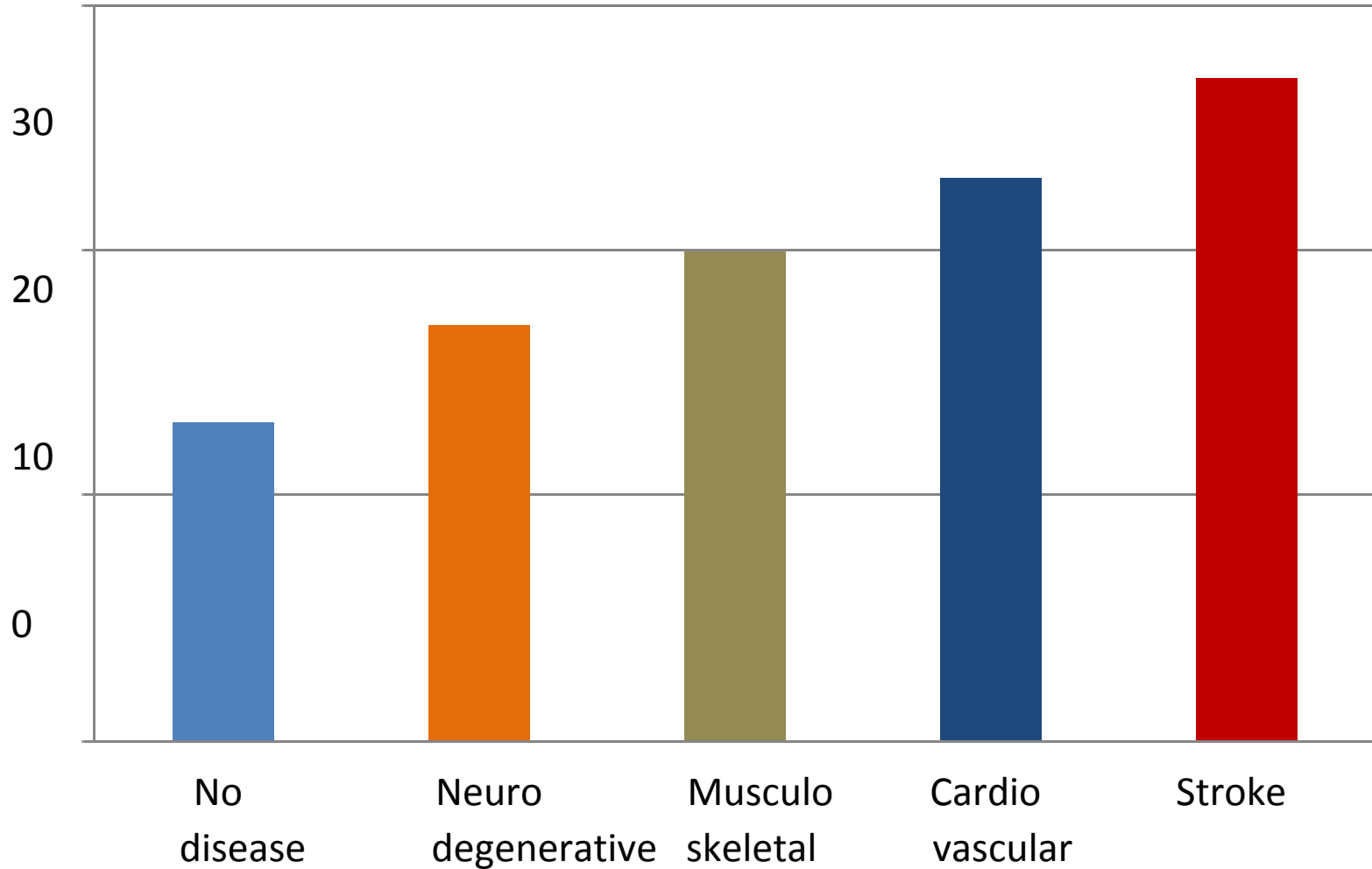
[www.statcan.gc.ca](http://www.statcan.gc.ca)





# Physical activity is low for persons with stroke in the community

Percent reporting “No leisure-time physical activity”





# Stroke and physical inactivity increase cardiovascular risk

- Cardiovascular disease is the leading prospective cause of death in chronic stroke
- 75% with heart disease
- 85% with hypertension
- 80% with impaired glucose tolerance or diabetes
- 1/3 go on to have another stroke within 5 years



# Classification of Blood Pressure

Category	Systolic BP mmHg		Diastolic BP mmHg
<b>Normal</b>	<b>&lt; 120</b>	<b>AND</b>	<b>&lt; 80</b>
<b>Prehypertension</b>	<b>120-139</b>	<b>OR</b>	<b>80-89</b>
<b>Hypertension Stage 1</b>	<b>140-159</b>	<b>OR</b>	<b>90-99</b>
<b>Hypertension Stage 2</b>	<b>≥160</b>	<b>AND</b>	<b>≥100</b>

# Why engage in physical activity after a stroke?



**“What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?”**



# Stroke and physical inactivity increase cardiovascular risk

- Inactivity and low cardiovascular fitness is a modifiable risk factors of cardiovascular disease
- Individuals with even mild stroke are in 10% percentile for cardiovascular fitness ( $VO_2$ max) for age-matched norms



## Effect of aerobic exercise in stroke

- Can reduce blood pressure
- Can improve lipid profiles
- Can improve glucose and insulin profiles

- ↓10 mmHg systolic resting SBP → ↓ risk of stroke by 1/3
- ↑1% HDL-C → 2-3% ↓ coronary heart disease

**We can save lives with aerobic exercise!**



## How intensive is our cardiovascular training in therapy?

How many minutes is the heart rate within a training zone (40-85% of heart rate reserve) during a typical inpatient stroke session

..during PT

..during OT

0            10            20            >20 min

2.8 min of the 55 min PT sessions and 0.7 min of the 41 min OT sessions

MacKay-Lyons et al. 2002



# Many modalities of aerobic exercise

# Effect of a water-based aerobic program

- Chest-deep exercise
- 8 weeks, 3X/week, 30 min
- Life-belt/life jacket
- Watershoes

*A randomized controlled trial of water-based exercise for cardiovascular fitness in individuals with chronic stroke. Chu, Eng et al. Arch Phys Med Rehab (2004)*



### Improvements in

- VO<sub>2</sub>max – 22%
- Gait speed
- 6MWT distance
- Muscle strength
  
- No change in balance

- May need to vary task so muscle fatigue does not limit aerobic workout
- Stepping while holding a rail
- High stationary stepping
- Stepping on platform, stair or stepper
- Stationary bicycle
- Treadmill
- Walking
- Side stepping
- Sit-to-stand
- Walking exercises





## Key issues in adapting aerobic training for stroke

- For deconditioned cardiac patients, the training threshold is usually between 40-50% maximum oxygen uptake (min 50% heart rate max)
- Intermittent bouts can be used to gradually increase fitness
- Due to deficits, walking may not be effective for increasing heart rate
- Maximal exercise test (stress test) is recommended for protocols > 40% heart rate reserve (50% heart rate max)
- Patients on beta blockers may require monitoring by RPE

- **Osteofit (osteoporosis)**
- **Aquafit**
- **Better Backs and Balance**
- **Joint Works (arthritis)**
- **Tai Chi**
- **Mall Walking clubs**

# Thank you for listening.



Michael Smith Foundation for  
**Health Research**



HEART &  
STROKE  
FOUNDATION  
OF BC & YUKON

*Finding answers. For life.*



CIHR IRSC

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