

Cardiovascular Fitness Training after Stroke: Rehabilitation and Secondary Prevention

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Slide 2

Acknowledgments

- CIHR
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- Canadian Stroke Network 
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Collaborators

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Outline

Part 1

- Cardiovascular disease & stroke
- Fitness levels post-stroke
- Secondary stroke prevention
- Fitness training after stroke

Part 2

- Treatment tips for CV fitness training after stroke

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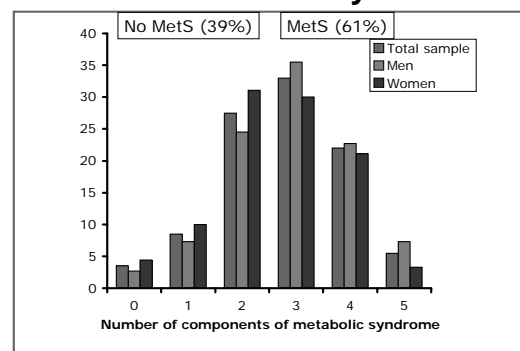
CV Disease & Stroke

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- Stroke is leading cause of disability in Canada.
- Stroke & cardiac disease share same risk factors (*Wolf, 1999*).
- Metabolic Syndrome (MetS) - clustering of metabolic factors that accelerate vascular disease
- MetS = 3 or more of these components:
 - Obesity (BMI > 30)
 - Hypertension (SBP > 130 or DBP > 85)
 - Elevated triglycerides (> 1.69 mmol/l)
 - Low HDL (< 1.03 in men/<1.29 in women)
 - Insulin resistance (DM or serum glucose > 6.1)

Stroke & Metabolic Syndrome

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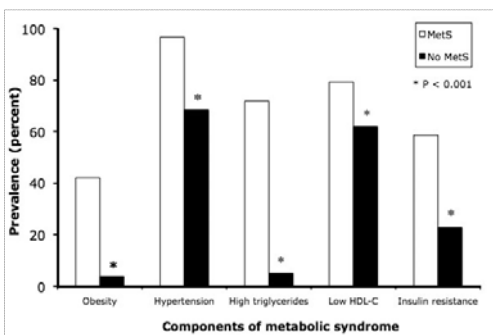


MacKay-Lyons et al, JNPT, 2009

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Stroke & Metabolic Syndrome

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MacKay-Lyons et al, JNPT, 2009

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CV Disease & Stroke

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- < 1/3 of disability post-stroke can be explained by severity of neurological impairment. (Roth, 1998)
- CV disease may be more disabling than the stroke itself. (Gresham, 1979)
- Cardiac disease is the leading cause of mortality in stroke survivors (Roth, 1994).
- An estimated ~70% of strokes could be prevented by better control of modifiable risk factors. (Sacco, 2006)

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CV Disease & Stroke

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Cardiovascular Health
Cardiovascular Events
Cardiovascular Disease

Cerebrovascular Health
Cerebrovascular Events
Cerebrovascular Disease



Vascular Health
Vascular Events
Vascular Disease

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Exercise Capacity

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- Exercise capacity = CV fitness = limit in ability to respond to physiologic stresses of prolonged physical effort
- Gold standard for measuring exercise capacity = VO_2 max or VO_2 peak
- Oxygen consumption (VO_2)
$$VO_2 = HR \times SV \times A-VO_2\text{diff}$$
- VO_2 increases linearly with workload:
15-25% of O_2 removed at rest & 75-85% during max exercise

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Exercise Capacity After Stroke

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- Need a reliable, valid, and safe method of measuring VO_2 peak after stroke.



MacKay-Lyons et al, 2001

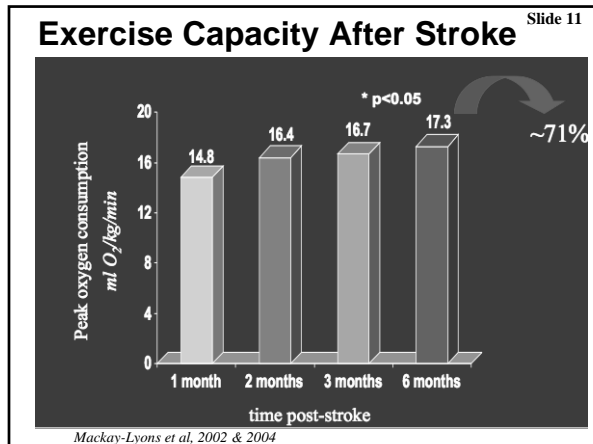
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Exercise Capacity After Stroke

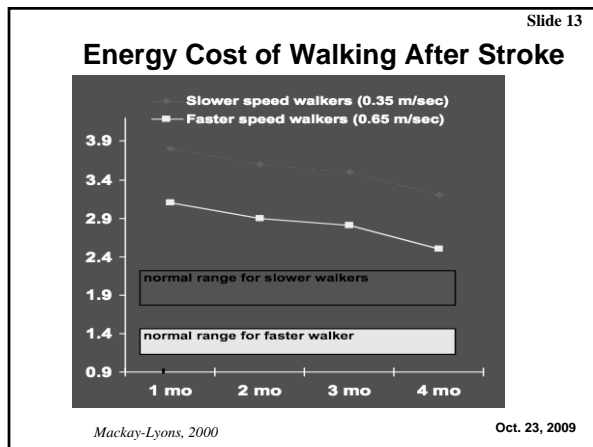
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- CV fitness levels of people post-stroke are abnormally low.

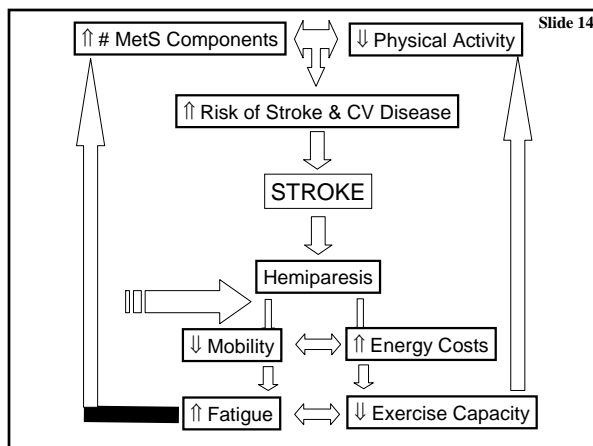
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- ### Exercise Capacity & Fatigue
- Slide 12
- Fatigue is one of the main concerns of people post-stroke.
 - About a third of the fatigue can be attributed to depression. (*Inglis et al, 1999*)
 - Energy costs of daily tasks are ~2-3 times higher after stroke, decreasing energy reserves.
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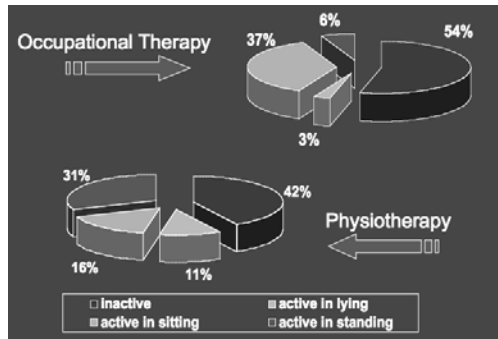
- ### Secondary Stroke Prevention
- Slide 7
- ~20-25% of people post-stroke will have a second stroke/CV event within 3 years.
 - Risk of recurrence is greatest in first year (12%). (*Hankey, 2003*)
 - Secondary strokes account for ~1/3 of all new strokes each yr. (*Rosamond, 2006*)
 - Recurrent strokes have higher fatality rates.
 - Second stroke survivors experience long-term disability and institutionalization. (*Hankey, 2005*)
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- ### Fitness Training After Stroke
- Slide 15
- Exercise is a very potent physiologic stimulus.
 - Cardiac rehabilitation increases fitness levels & reduces CV-related morbidity & mortality. (*Taylor, 2004*)
 - Usual care stroke rehabilitation does not include fitness training. (*MacKay-Lyons, 2002*)
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Exercise Intensity of Stroke Rehabilitation

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Mackay-Lyons et al 2002

Early Training Trials Post-Stroke

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- Potempa (1995): RCT - 42 chronic subjects; 10-week program of bicycle ergometry ⇒ 13% vs 1% change in VO_{2peak}
- Macko (1997): 9 chronic males; 6-month program of treadmill conditioning ⇒ 15% change in HR_{submax} at a fixed workload
- Fujitani (1999): 30 chronic males; 10-month home exercise program ⇒ 19% change in VO_{2peak}
- Duncan (2003): RCT - 100 subacute subjects 2-3 week program; (20 min/day) ⇒ higher VO_{2peak} , workload, exercise time

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Fitness Training Early After Stroke: Participants

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Inclusion Criteria

- In-patient
- Post-stroke interval < 1 month
- Locomotor FIM score ≥ 3
- Residence within 50 km of rehab centre

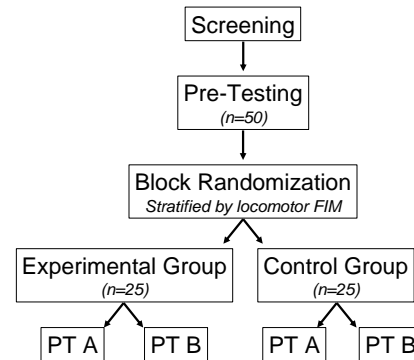
Exclusion Criterion

- Presence of contraindications with cardiology screening examination

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Study Design

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Trial Interventions

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BWSTT Group

Active UE/LE exercises 20-25 min
 BWSTT 30-35 min
 warm-up 5 min
 aerobic training (40-60% VO_{2peak}) 20-25 min
 cool-down (25-30% VO_{2peak}) 5 min

Usual Care Group

UE exercises 10-15 min
 LE/trunk exercises 15-20 min
 Balance/mobility exercises 20 min
 Resting between exercises 10 min

Both Groups

Home exercise program after discharge with telephone follow-up ~ once a month

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Intervention Schedule

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Both Groups

60 min/day, 5 days/week for 6 weeks
 60 min/day, 3 days/week for 6 weeks
 Total of 48 sessions

Intervention Audits

Both Groups

every 4 weeks
 continuous heart rate recording
 record of exercises/activities
 duration of exercises/activities
 feedback to physiotherapist

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Results

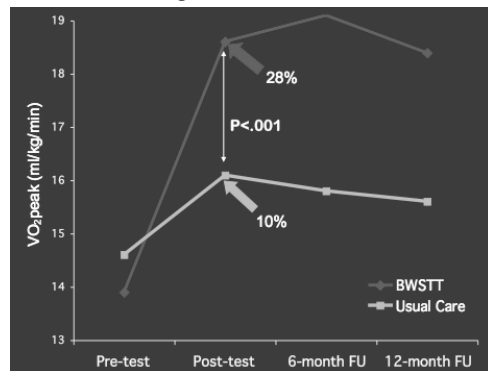
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- 3 BWSTT subjects & 2 Usual Care subjects did not complete the 12-week intervention; final n=45.
- Overall attendance rate was 94%.
- No adverse events occurred during testing/training sessions.

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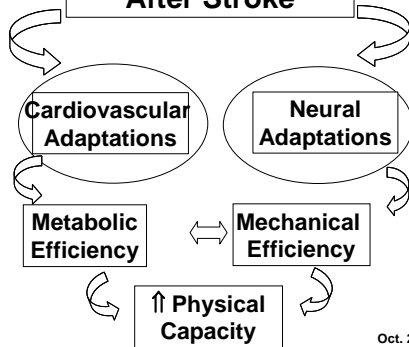
Preliminary Results - VO₂peak

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FITNESS TRAINING After Stroke

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Nintendo Wii Study

N=25 patients post-stroke (22 males:3 females)

Training targets

#1. %HR_{maxpred} ≥ 64% #3. % HRR_{pred} ≥ 40%

#2. METs ≥ 3

#4. RPE₀₋₁₀ ≥ 4

Preliminary results

87% met 1 target

64% met 2 targets

55% met 3 targets

36% met all 4 targets

PREVENT TRIAL

Program of Rehabilitative Exercise/Education to avert Vascular Events after Non-disabling stroke or Transient ischemic attack



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Tip #1 Safety & Screening

Slide 26

- Screening is important
 - Cardiac history
 - Symptoms
 - ✓ SOB at rest
 - ✓ Orthopnea
 - ✓ Bilateral ankle swelling
- Pre-training exercise stress test
- Adverse event protocol
- Pulse oximetry if O₂ saturation < 85%

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Tip #2 Patient Selection

- *Age & sex*: no effect on trainability (Lewis, 1986).
- *Time* (subacute vs chronic): optimal time is unknown.
- *Spasticity*: not a contra-indication; training may ↓ muscle tone due to reflex modulation (Trimble, 1998).

Tip #3 Training Environment

- Wheelchair accessible & free of obstacles.
- Stimulating environment (music, mirrors, posters, bright colors, natural light).
- High-risk individuals need quick access to emergency medical personnel & equipment.
- Low-risk individuals, after appropriate screening, can exercise safely in supervised community (Eng, 2003) or home settings. (FITStudy)

Tip #4 Preparation for Training

- Comfortable clothing & supportive footwear to prepare patient physically & psychologically for training.
- Eating & coffee should be avoided ~2 hours before training.
- Water cooler to prevent dehydration.
- Fan to offset thermal dysregulation.

Tip #5 Personnel

- If locomotor FIM ≤ 3 (moderate assist) 2-person support may be needed initially.
- Training in groups with adequate supervision has been shown to be effective. (Eng, 2003)

Tip #6 Scheduling

- Most important factors are participants' needs & desires - must be convenient.
- If easily fatigued, train in morning (lowest circadian body temperature).
- Coordinate training with medication schedule, if necessary.

Tip #7 Duration of Program

- In non-disabled population, 4-6 weeks needed for meaningful increase in exercise capacity (i.e., > 10% improvement). (Saltin, 1977)
- Duration of study trials has ranged from 2 weeks to 10 months.
- Training must be sustained indefinitely to prevent return to the deconditioned state - 25% reduction in fitness after 3 weeks of bed rest (Convertino, 1982).

Tip #8 Program Frequency

- American College of Sports Medicine (ACSM) recommend “*most days of the week*”.
- 3-4 days/week is commonly used although fitness can improve 2x/week sessions.

Tip #9 Mode of Training

- Task specificity of training.
- Large muscle groups.
- Rhythmic, alternating movements. Music of an appropriate cadence can potentiate muscle activation. (*Rossignol, 1976*)
- Treadmill +/- body weight support, overground walking program, stationary bike, arm bike, arm-leg bike, circuit training, aquatics.
- Nintendo Wii (?)

Tip #10 Strength Training

- Resistance training improves CV fitness outcomes. (*Pierson, 2001*)
- Strengthening decreases cardiac demands of daily tasks, e.g., lifting objects or carrying groceries. (*Hickson, 1980*)
- Strengthen 2-3x/week, 8-12 repetitions starting with low weight & avoiding Valsalva maneuver. (*ACSM*)
 - Abdominals
 - Triceps, biceps
 - Hip abductors
 - Hip & knee extensors
 - Hip & knee flexors
 - Plantarflexors & dorsiflexors

Tip #11 Components of Program

- 5-10 min warm-up & cool-down of aerobic exercise at lower intensity
- Training initiated in 5-minute "bouts" with 1-2 min rest periods between bouts.
- Minimal time for training session is 30 minutes.
- Increase length of bouts & reduce rest periods over time

Tip #12 Intensity of Training

- Most difficult aspect - metabolic load must be challenging but not excessive.
- Initial intensity & progression must be individualized, using heart rate or VO_2 peak data.
- Dose-response relationship between intensity & benefit:
 - For *CV health* - low-to-mod intensities
 - For *CV fitness/reduction in CV risk factors* - mod-to-high intensities. (*ACSM*)

Tip #12 Intensity of Training (cont'd)

Training intensity is often based on heart rate:

1. $HR_{rest} + X$ beats {often $X = 20$ for special populations}
 2. $X\%$ of $HR_{max-pred} = X\%$ of $220 - age$ {often $X = 40\%$ for deconditioned patients}
 3. Karvonen: $X\%$ of Heart rate reserve (HRR)

$$= X\% [HR_{max-pred} - HR_{rest}] + HR_{rest}$$
- ❖ If on Beta blockers use adjusted $HR_{max-pred} = 85\% [220 - age]$

Tip #12 Intensity of Training Slide 39 (cont'd)

We classify participants post-stroke into 3 groups:

<i>Low Intensity</i> < 40% of HHR	<i>Moderate Intensity</i> 40-60% of HRR	<i>High Intensity</i> > 60% of HHR
Precautions due to ECG +/- BP +/- HR response	Mild-mod abnormalities in ECG +/- BP +/- HR response	Normal ECG +/- BP +/- HR response
Very deconditioned (VO ₂ peak < 40% predicted)	Quite deconditioned (VO ₂ peak 40- 60% predicted)	Somewhat deconditioned (VO ₂ peak > 60% predicted)
Very poor LE motor control (Stage 1-2)	Poor LE motor control (Stage 3-4)	Moderate LE motor control (\geq Stage 5)

Tip #12 Intensity of Training Slide 40

Rating of Perceived Exertion (RPE) is a valid proxy (ACSM, 2005).

Rating	Description
0	Nothing at all
.5	Extremely light
1	Very light
2	Light
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Extremely hard (almost maximal)

or 11-13
on RPE₄₋₂₀
scale

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Tip #13 Progression of Training Slide 41

- Progress individually - higher the baseline fitness level the more rapid the progression.
- Progress over a 3-6 month period: from a *conditioning phase*, to a *training phase*, and then to a *maintenance phase*.
- 1st target frequency (e.g., \geq 3 days/week).
- 2nd target duration, increasing at every 1-3 weeks (e.g., \geq 20-30 minutes).
- 3rd target intensity.

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Tip #14 Clinical Outcome Measures Slide 42

- 6-min walk distance walked in 6 minutes, with or without rests.
- Shuttle walk test walking is initiated at an audio-guided set pace for a prescribed length of time. Speed is increased at each stage until the subject can no longer maintain pace.
- Heart rate at a fixed submaximal load
- MetS components vascular risk factors

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Tip #15 Adherence to Training Slide 43

- Gradually progress exercise intensity.
- Establish regularity of training sessions.
- Minimize risk of muscular soreness.
- Exercise in groups, emphasizing enjoyment.
- Provide ongoing positive reinforcement
- Use activity logs & charts to record progress.
- Schedule at a convenient time & in an accessible location.
- Offer assistance with transportation, child care.

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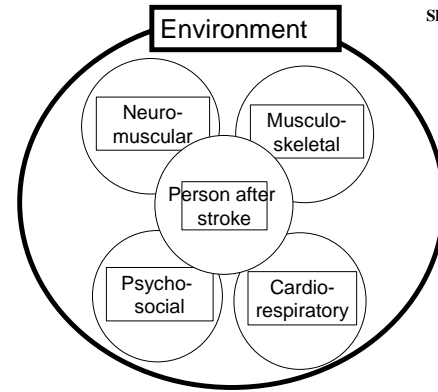
“What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?”

Tip #16 Lifestyle Modifications

Slide 45

- Aerobic training alone is insufficient - need other lifestyle modifications to improve health status & QOL.
- Gradually incorporate exercises into everyday life (e.g. mall walking, cycling while watching TV).
- Nutritional counseling is important - early after stroke patients consume only 80-91% of required energy & protein (Foley, 2006).
- Counseling on energy conservation techniques, smoking cessation and coping strategies is essential.

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References

- American College of Sports Medicine. *ACSM's Guidelines for Exercise Testing and Prescription*. edition. Lippincott Williams and Wilkins, 2006.
- Convertino V. Cardiovascular response to exercise in middle-aged men after 10 days of bedrest. *Circulation*. 1982; 65: 134-40.
- Duncan P, Studenski S, Richards L, et al. Randomized clinical trial of therapeutic exercise in subacute stroke. *Stroke*. 2003; 34: 2173-80.
- Eng JJ, Chu KS, Kim CM, Dawson AS, CArswell A, Hepburn KE. A community-based group exercise program for persons with chronic stroke. *Med Sci Sports Exerc*. 2003; 35: 1271-78.
- Fujitani J, Ishikawa T, Akai M, Kakurai S. Influence of daily activity on changes in physical fitness for people with post-stroke hemiplegia. *Am J Phys Med Rehabil*. 1999; 78: 540-44.
- Gresham GE, Phillips TF, Wolf PA, McNamara PM, Kannal WB, Dawber TR. Epidemiologic profile of longterm stroke disability: the Framingham Study. *Arch Phys Med Rehabil*. 1979; 60: 487-91.
- Foley N, Finestone HM, Woodbury MG, Teasell RW, Greene Finestone L. Energy and protein intake of acute stroke patients. *J Nutr Health Aging*. 2006; 10: 171-75.
- Hankey GJ. Long-term outcome after ischemic stroke/ischemic attack. *Cerebrovasc Dis*. 2003; 16 Suppl 1: 14-9.

References

- Hankey GJ. Redefining risks after TIA and minor ischaemic stroke. *Lancet*. 2005; 365: 2065-6.
- Hickson RC, Rosenkoetter MA, Brown MM. Strength training effects aerobic power and short-term endurance. *Med Sci Sports Exerc*. 1980; 12: 336-39.
- Ingles JL, Eskes GA, Phillips SJ. Fatigue after stroke. *Arch Phys Med Rehabil*. 1999; 80: 173-78.
- Lewis DA, Kamon E, Hodgson JL. Physiological differences between genders. Implications for sports conditioning. *Sports Med*. 1986; 3: 357-69.
- MacKay-Lyons M, Makrides L, Speth S. Effect of 15% body weight support on exercise capacity of adults without impairments. *Phys Ther*. 2001; 81: 1790-800.
- MacKay-Lyons M, Makrides L. Cardiovascular stress during stroke rehabilitation: Is the intensity adequate to induce a training effect? *Arch Phys Med Rehabil*. 2002; 83: 1378-83.
- MacKay-Lyons M, Makrides L. Exercise capacity early after stroke. *Arch Phys Med Rehabil*. 2002; 83: 1697-702.
- MacKay-Lyons M, Makrides L. Longitudinal changes in exercise capacity after stroke. *Arch Phys Med Rehabil*. 2004; 85: 1608-12.
- MacKay-Lyons M, MacDonald C, Howlett J. Metabolic syndrome and its components in individuals undergoing rehabilitation after stroke. *J Neurol Phys Ther*. 2009; In Press.

References

- MacKay-Lyons M, McDonald A, Matheson J, Hollett J. Physiological changes following a 12-week program of body-weight supported treadmill training early post-stroke: a randomized clinical trial. 2009; In review.
- Macko RF, Katzel LI, Yataco A, et al. Low-velocity graded treadmill stress testing in hemiparetic stroke patients. *Stroke*. 1997; 28: 988-92.
- Pierson LM, Herbert WG, Norton HJ, al. e. Effects of combined aerobic and resistance training versus aerobic training alone in cardiac rehabilitation. *J Cardiopulm Rehabil*. 2001; 21: 101-10.
- Potempa K, Lopez M, Braun LT, Szidon P, Fogg L, Tincknell T. Physiological outcomes of aerobic exercise training in hemiparetic stroke patients. *Stroke*. 1995; 26: 101-05.
- Rosamond WD, Flegal K, Furie K, Go A, Greenlund KJ, Hasse N. Heart disease and stroke statistics-2008 update: areport from the American Heart Association Statistics Committee. *Circulation*. 2006; 117: e25-e146.
- Rossignol S, Jones GM. Audio-spinal influence in man studied by the H-reflex and its possible role on rhythmic movements synchronized to sound. *Electroenceph Clin Neurophysiol*. 1976; 41: 83-92.
- Roth E. Heart disease in patients with stroke. Part II: Impact and implications for rehabilitation. *Arch Phys Med Rehabil*. 1994; 75: 94-101.

References

- Roth EJ, Heinemann AW, Lovell LL, Harvey RL, McGuire JR, Diaz S. Impairment and disability: Their relation during stroke rehabilitation. *Arch Phys Med Rehabil*. 1998; 79: 329-35.
- Sacco RL, Adams R, Albers G, et al. Guidelines for Prevention of Stroke in Patients With Ischemic Stroke or Transient Ischemic Attack: A Statement for Healthcare Professionals From the American Heart Association/American Stroke Association Council on Stroke: Co-Sponsored by the Council on Cardiovascular Radiology and Intervention: The American Academy of Neurology affirms the value of this guideline. *Circulation*. 2006; 113: e409-e49.
- Taylor RS, Brown A, Ebrahim S, et al. Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. *Am J Med*. 2004; 116: 682-92.
- Trimble MH, Kukulka C, Behrman AL. The effect of treadmill gait training on low-frequency depression of the soleus h-reflex: Comparison of a spinal cord injured man to normal subjects. *Neurosci Lett*. 1998; 246: 186-88.
- Wolf PA, Clagett GP, Easton JD, et al. Preventing ischemic stroke in patients with prior stroke and transient ischemic attack: a statement for healthcare professionals from the stroke council of the American Heart Association. *Stroke*. 1999; 30: 1991-94.

The End!!

