Physical Activity and Exercise Programming for Stroke Survivors Across the Continuum of Care

Rationale, evidence & possible synergies

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Outline

- Rationale for physical activity and exercise
- Evidence and examples of fitness/physical activity programs across the continuum of care
- Discussion of synergies

Why physical activity/exercise training post-stroke?

	Total (N=55)
Age (mean±SD)	59.6±10.2
Sex, n (%)	
Male	22 (40)
Female	33 (60)
Race, n (%)	
White	10 (18)
Black	37 (67)
Hispanic	6 (11)
Other	2 (4)
BMI (kg·m²) (mean±SD)	31.9±7.8
Affected side, n (%)	
Right	23 (42)
Left	28 (51)
Unknown	4 (7)
VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) (mean±SD)	13.0±4.9
Comorbidities, n (%)	
Diabetes	17 (31)
Hypertension	41 (75)
Congestive heart failure	4 (7)

Rimmer JH, Rauworth AE, Wang EC, Nicola TL, Hill B. Arch Phys Med Rehabil 2009;90(3):407-12.

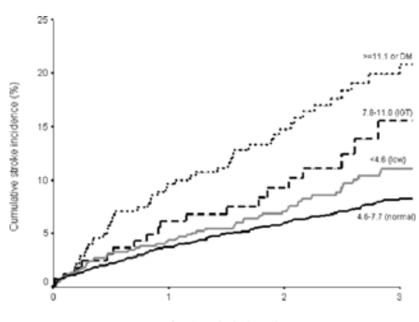
TABLE 1. Clinical and Demographic Features of Patients Randomized to Treadmill and Control Groups

Characteristic	Treadmill Exercise Group, n=32 (%)	Control Group, n=29 (%)
Age, y (mean±SD)	63±10	64±8
Gender, male:female	22:10	21:8
Race, black:white	20:12	15:14
Brain lesion side, right:left	18:14	13:16
Latency since stroke, mo (mean±SD)	35±29	39±59
Coronary artery disease	7 (22)	4 (17)
Hypertension	20 (63)	25 (86)
Diabetes mellitus	13 (41)	11 (38)
Former smokers	17 (53)	13 (45)
Current smokers	5 (16)	4 (14)
Ankle–foot orthoses	15 (47)	11 (38)
Assistive device		
None	11 (34)	6 (21)
Single-point cane	13 (40)	14 (48)
Quad cane	4 (13)	7 (24)
Walker	4 (13)	2 (7)

SD indicates standard deviation.

Macko RF et al. Stroke 2005;36(10):2206-11.

Kaplan-Meier curve of cumulative stroke incidence stratified by nonfasting glucose levels (in mmol/L)



Vermeer, S. E. et al. Stroke 2006;37:1413-1417

Stroke

American Stroke Association
A Division of American Heart Association

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Recurrent Stroke and Heart Disease

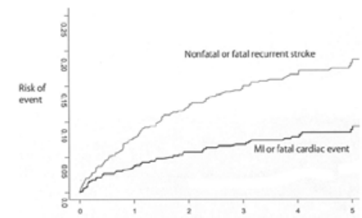


Figure 1. Kaplan–Meier survival curve comparing risk of nonfatal or fatal recurrent stroke with risk of myocardial infarction or fatal cardiac events.

Dhamoon MS, Sciacca RR, Rundek T, Sacco RL, Elkind MS. Recurrent stroke and cardiac risks after first ischemic stroke: the Northern Manhattan Study. Neurology 2006;66(5):641-6.

Physical Activity

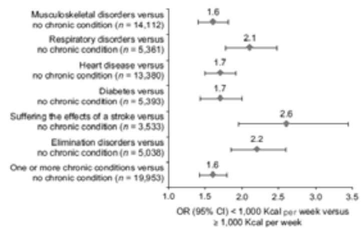
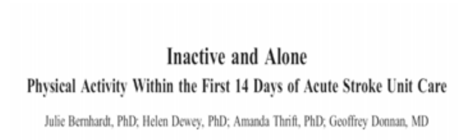
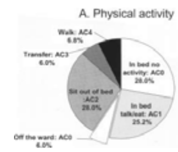
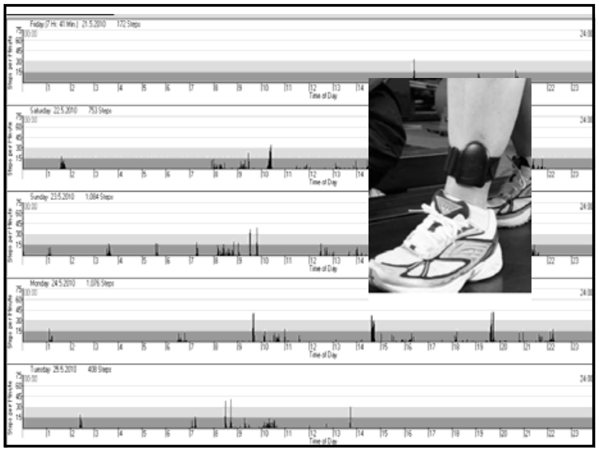


Figure 4
Odds ratios for physical activity in the chronic condition subsamples.

Sawatzky R, Liu-Ambrose T, Miller WC, Marra CA. Physical activity as a mediator of the impact of chronic conditions on quality of life in older adults. Health Qual Life Outcomes 2007;5:68.







Low Fitness Levels

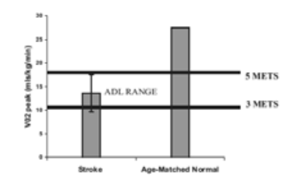


FIG. 1. Peak aerobic fitness levels (mean ± SD) of chronic stroke patients (n = 131) relative to the energy requirements for activities of daily living (ADL). Error bars represent standard deviation. Reproduced with permission from *Top Stroke Rehab* (Ref. 7).

Ivey FM, Hafer-Macko CE, Macko RF. Exercise rehabilitation after stroke. NeuroRx 2006;3(4):439-50.

Interventions

Acute Care

Fitness training in sub-acute stroke

- Intervention
  - 3 days per week, progressive cycling training
    - 30 minutes
    - 50-75% work rate achieved during peak test
    - Heart rate monitored but not used to monitor intensity

Tang A, Sibley KM, Thomas SG, Bayley MT, Richardson D, McIlroy WE et al. Effects of an aerobic exercise program on aerobic capacity, spatiotemporal gait parameters, and functional capacity in subacute stroke. Neurorehabil Neural Repair 2009;23(4):398-406.

Characteristics of Participants in Exercise Group (n = 23)

	n	Mean ± SE (range)
Men/Women	12/11	
Ischemic/Hemorrhagic/ Unknown stroke type	17/5/1	
Right/Left hemisphere affected	12/11	
Comorbidities		
Hypertension	16	
Hyperlipidemia	7	
Diabetes mellitus	2	
Coronary artery disease	1	
Chronic obstructive pulmonary disease	2	
History of smoking	7	
Anti-hypertensive medication use		
None/β-blockers/ACE inhibitors/Both	7/6/9/1	
Age, years		64.7 ± 3.6 (19–90)
Time poststroke, days		17.8 ± 3.1 (6–62)
Body Mass Index		26.3 ± 1.1 (17.6–37.4)
National Institutes of Health Stroke Scale score		4.7 ± 0.4 (2–11)
Chedoke-McMaster Stroke Assessment Leg score		4.4 ± 0.2 (3–6)
Functional Independence Measure score		84.9 ± 3.4 (57–113)

Abbreviation: ACE, angiotensin-converting enzyme.

Results

Table 3
Pretreatment and Posttreatment Scores for 18 Matched Pairs[a]

	Exercise Group			Control Group			P Value	
	Pretreatment	Posttreatment	% Change	Pretreatment	Posttreatment	% Change	Time	Group[b] Time
Aerobic capacity								
VO_2peak, $mL \cdot kg^{-1} \cdot min^{-1}$	11.6 ± 0.7	13.1 ± 0.9	12.6 ± 5.3	11.2 ± 0.5	12.1 ± 0.8	8.3 ± 4.5	.004	.71
Peak WR, watts	46.4 ± 4.3	57.2 ± 6.4	23.4 ± 11.0	43.5 ± 3.9	50.3 ± 5.2	15.5 ± 7.1	<.001	.62
Peak HR, beats/min	107.6 ± 4.8	112.4 ± 5.4	4.5 ± 3.1	107.6 ± 6.4	119.8 ± 6.4	11.4 ± 6.0	.002	.16
VeT, $mL \cdot kg^{-1} \cdot min^{-1}$	9.9 ± 0.6	10.3 ± 0.6	3.9 ± 4.8	9.0 ± 0.3	9.5 ± 0.5	6.0 ± 5.2	.09	.49
Gait assessment								
Preferred pace								
Gait speed, meters/second	0.68 ± 0.09	0.84 ± 0.08	33.3 ± 11.7	0.64 ± 0.1	0.82 ± 0.08	34.4 ± 12.1	<.001	.70
Gait symmetry (n = 20)	1.31 ± 0.11	1.28 ± 0.07	–8.3 ± 4.0	1.15 ± 0.03	1.15 ± 0.02	–0.1 ± 2.2	.06	.08
Gait symmetry (n = 11)[b]	1.53 ± 0.11	1.29 ± 0.04	–13.9 ± 4.6	1.22 ± 0.03	1.17 ± 0.02	–3.6 ± 0	.04	.14
Fast pace								
Gait speed, meters/second	0.99 ± 0.13	1.06 ± 0.11	16.6 ± 4.1	1.06 ± 0.12	1.19 ± 0.1	15.0 ± 5.3	<.001	.78
Gait symmetry (n = 20)	1.24 ± 0.08	1.28 ± 0.07	3.2 ± 1.9	1.15 ± 0.05	1.11 ± 0.01	–2.5 ± 2.3	.09	.85
Gait symmetry (n = 11)[b]	1.35 ± 0.08	1.28 ± 0.05	–5.6 ± 0	1.23 ± 0.06	1.14 ± 0	–6.4 ± 2.3	.02	.82
Functional ambulation								
6MWT distance, meters (% predicted)	207.0 ± 46.6 (50.0%)	334.2 ± 33.1 (65.3%)	52.7 ± 19.7	198.9 ± 40.2 (52.7%)	288.4 ± 38.9 (63.9%)	22.7 ± 5.6	<.001	.23
Health-related quality of life								
SIS Physical subscale	47.3 ± 2.8	72.4 ± 3.8	52.9 ± 8.6	45.3 ± 4.3	67.1 ± 4.6	47.9 ± 6.5	<.001	.22

Abbreviations: WR, work rate; HR, heart rate; VeT, ventilatory threshold; 6MWT, 6-Minute Walk Test; SIS, Stroke Impact Scale.
[a] Values are mean ± SE.
[b] *Post hoc* gait symmetry analysis using participants with asymmetric gait at study entry only.

Take home messages

- Safe
- All ability levels
- Improvements in some outcomes
- Will starting earlier help with later retention?

Interventions

Community

Outpatient Physical Training – Gait performance and CV health

(Jorgensen et al., Physical Therapy, 2010)

- 12 week intervention, 5 X weekly X 90 minutes
- BWSTT (all days), Aerobic exercise (2 day), PRST (3 days), functional training (weeks 4 and 10)

Table 1.
Demographic and Medical Characteristics of Participants[a]

Characteristic	Minimum	Maximum	Percentiles 25%	50%	75%	$\bar{X}$ (SD)
Age at injury (y)	51.3	70.1	53.3	57.7	61.3	58.4 (6.1)
Age at program entry (y)	52.4	71.4	55.9	58.9	63.6	60.4 (5.7)
Time between injury and beginning of training (mo)	2.7	84.7	6.5	18.1	31.3	24.6 (23.1)
Amount of training before intervention (h/wk)	0.0	6.0	1.9	2.8	4.2	3.0 (1.7)

[a] Thirteen participants (93%) were men, and 1 participant (7%) was a woman.

- All but one used walking aid, 12/14 used AFO
- Walking speed <1/2 normal
- No active DF or eversion, no active isolated hip or knee F

Jorgensen, J. R. et al. PHYS THER 2010;90:527-537

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Table 3.
Test Results Obtained Before and After Program

Test	No. of Participants	Before Program $\bar{X}$ (SD)	Before Program Median	After Program $\bar{X}$ (SD)	After Program Median	Mean Difference (95% Confidence Interval)	P*
Systolic blood pressure (mm Hg)	12	142.3 (17.7)	144.5	127.6 (14.2)	126.0	14.7 (6.2–23.2)	.005
Diastolic blood pressure (mm Hg)	12	88.0 (10.2)	87.0	78.3 (10.3)	78.5	9.7 (3.2–16.1)	.017
Resting heart rate (bpm)	12	70.3 (10.6)	73.0	66.9 (11.0)	63.5	3.4 (−2.2–9.1)	.27
Body mass index (kg/m²)	11	28.9 (4.3)	28.5	28.1 (4.3)	27.5	0.8 (0.2–1.4)	.005
Six-Minute Walk Test (km/h)	14	2.1 (1.1)	2.1	3.4 (1.3)	3.8	1.3 (1.0–1.6)	<.001
10-Meter Walk Test (s)	14	18.9 (12.2)	14.5	11.5 (9.1)	8.4	7.4 (4.4–10.4)	.001
Estimated aerobic capacity (mL O_2/min/kg)	5	22.4 (3.8)	21.7	26.5 (2.7)	26.0	4.1 (−0.7–8.9)	.08
Self-rated maximum walking distance (m)	11	1,570.5 (1,546.0)	1,500.0	3,171.4 (2,041.4)	3,000.0	1,601 (679–2,523)	.003

* As determined with the Wilcoxon matched-pairs signed rank test (1-tailed).

Six Minute Walk Test – 210 m (Pre), 340 m (Post)

Gait Speed – 31.8 m/min (Pre), 52.2 m/min (Post)

Jorgensen, J. R. et al. PHYS THER 2010;90:527-537

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Results

- Reduction in blood pressure SBP 14 mmHg, DBP 10 mmHg
  - 5 mmHg blood pressure reduction results in 20-25% reduction in stroke risk (McAlister et al; Implementation Science; 2010, 5: 27).

Moderate vs. Low Intensity Exercise

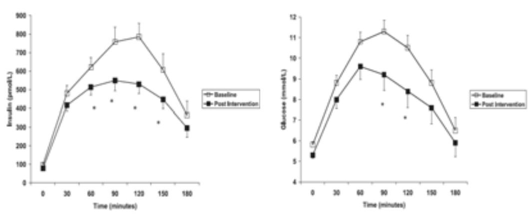
Table 3: Outcome Measures by Pre-Posttest and Experimental Condition

Variables	MISD (n=14) Pretest	MISD Posttest	MISD Effect Size	MISD P*	LILD (n=14) Pretest	LILD Posttest	LILD Effect Size	LILD P*	TE (n=13) Pretest	TE Posttest	TE Effect Size	TE P*
Cardiorespiratory fitness												
BMI (kg.m²)	33.3±9.0	33.2±9.1	.011	.818	30.5±5.7	30.5±5.3	0.009	.887	29.6±5.4	29.4±5.1	.038	.432
Submaximal $\dot{V}O_2$(40W)	10.61±3.8	9.36±2.3	.398	.190	9.57±2.0	8.95±1.8	0.329	.371	9.59±2.2	9.89±2.8	.119	.509
VO_{2peak} (mL·kg^{-1}·min^{-1})	15.06±7.4	15.71±7.6	.087	.239	13.27±3.6	14.02±3.9	0.200	.279	12.57±4.2	12.22±3.6	.090	.467
Blood pressure												
Diastolic (mmHg)	77.7±10.3	69±12.6	.756	**.002**	84.2±10.4	78.3±13.6	0.487	.081	77.3±11.5	76.8±8.8	.049	.875
Systolic (mmHg)	129.5±13.5	119.2±22.0	.564	**.048**	130.7±13.2	122.3±22.3	0.458	.188	130.3±17.3	127.7±15.6	.158	.575
Lipid panel (mg/dL)												
Total cholesterol	173.6±25.6	158.2±16.3	.718	**.036**	182.4±35.5	170.3±19.1	0.424	.113	196.1±41.8	196.3±50.9	.004	.963
HDL-C	52.5±14.8	51.9±16.1	.039	.747	57.8±27.5	54±21.4	0.154	.340	57.7±18.3	59.2±23.3	.072	.475
LDL-C	101±23.4	91.4±16.6	.473	.192	96.7±29.8	96.1±16.9	0.025	.935	113.2±35.1	119.5±40.3	.167	.280
TG	100.6±42.4	73.8±29.9	.731	**.029**	139.8±61.9	106.4±70.5	0.503	**.045**	113.1±63.1	92.6±40.8	.386	.128

NOTE. Values are mean ± SD unless otherwise indicated. Boldface values indicate statistical significance (ie, < .05).
*Paired *t* test; 4, 5, and 5 subjects in MISD, LILD, and TE groups, respectively, did not complete the posttest.

Rimmer JH, Rauworth AE, Wang EC, Nicola TL, Hill B. A preliminary study to examine the effects of aerobic and therapeutic (nonaerobic) exercise on cardiorespiratory fitness and coronary risk reduction in stroke survivors. Arch Phys Med Rehabil 2009;90(3):407-12.

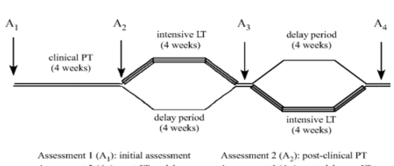
Treadmill Training – Glucose Tolerance



Ivey FM, Ryan AS, Hafer-Macko CE, Goldberg AP, Macko RF. Treadmill aerobic training improves glucose tolerance and indices of insulin sensitivity in disabled stroke survivors: a preliminary report. Stroke 2007;38(10):2752-8.

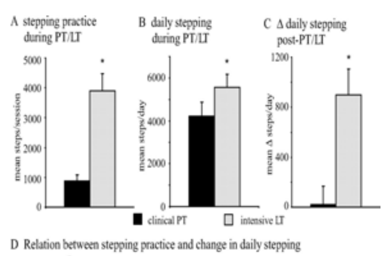
Locomotor Training Improves Daily Stepping Activity and Gait Efficiency in Individuals Poststroke Who Have Reached a "Plateau" in Recovery

Jennifer L. Moore, PT, NCS; Elliot J. Roth, MD; Clyde Killian, PhD, PT; T. George Hornby, PhD, PT



Clinical PT – determined by treating therapists

Intensive LT – high intensity stepping practice, wearing overhead harness, highest tolerable speed. HR 80-85% age predicted max.



D Relation between stepping practice and change in daily stepping

- Steps outside of clinical PT = 3321
- Steps outside intensive LT = 1664

Moore, J. L. et al. Stroke 2010;41:129-135

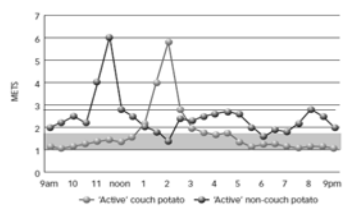
Circuit-Based Rehabilitation Improves Gait Endurance but Not Usual Walking Activity in Chronic Stroke: A Randomized Controlled Trial

Suzie Mudge, PhD, P. Alan Barber, PhD, N. Susan Stott, PhD

- Circuit training sessions 3 X per week times 4 weeks
- Improvements in 6MW distance post intervention, not maintained at 3 months
- No change in physical activity during or after intervention
- Did no change in PA, affect follow-up results?

Why concentrate on physical activity?

Figure 3: A Hypothetical Representation of the Physical Activity and Sedentary Patterns and Energy Equivalent (METS) Over a 12-hour Day for Two Individuals, Both of Whom Participate in Equivalent Amounts of Health-enhancing Physical Activity*



Dunstan, Healy et al 2010 at: http://www.touchendocrinology.com/files/article_pdfs/owen.pdf

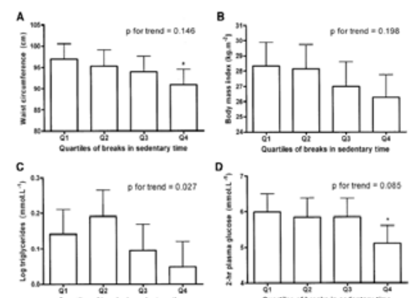


Figure 1—*Quartiles of breaks in sedentary time with metabolic risk variables: waist circumference (A), BMI (B), triglycerides (C), and 2-h plasma glucose (D). Estimated marginal means (SE) adjusted for age, sex, employment, alcohol intake, income, education, smoking, family history of diabetes, diet quality, moderate- to vigorous-intensity time, mean intensity of breaks, and total sedentary time. Triglycerides (log) are additionally adjusted for lipid-lowering medication. Cut points for quartiles were 506, 612, and 673 breaks; *P < 0.05 compared to quartile 1.*

Healy GN, Dunstan DW, Salmon J, Cerin E, Shaw JE, Zimmet PZ et al. Breaks in sedentary time: beneficial associations with metabolic risk. Diabetes Care 2008;31(4):661-6.

LIFE-P

TABLE 1. Lifestyle Interventions and Independence for Elders Pilot (LIFE-P) physical activity schedule.

Phase	Center-Based Physical Activity	Behavioral Group Counseling Sessions	Home-Based Physical Activity	Telephone Counseling Contact
Adoption (weeks 1–8)	Three times each week	Eight scheduled meetings, immediately after a scheduled center-based physical activity session	Up to two times per week	One time per month
Transition (weeks 9–24)	Two times each week	Two scheduled meetings	Three times per week	One time per month
Maintenance (week 25 to end of the trial)	Offered once per week		Five or more times per week	One time per month

Those who adhered to activity at 12 months had better functional status

Fielding RA, Katula J, Miller ME, Abbott-Pillola K, Jordan A, Glynn NW et al. Activity adherence and physical function in older adults with functional limitations. Med Sci Sports Exerc 2007;39(11):1997-2004.

Possible synergies

Fitness facilities, cardiac rehabilitation, chronic disease management

Fitness Facilities

- Survey of programming in fitness facilities in Toronto (Fullerton et al., Appl Physiol Nutr Metab; 2008)
  - 12% of facilities offered programs for people with stroke
  - Mostly not-for-profit organizations
  - Education sessions included in 65%
    - Focus on nutrition, community resources, not signs of stroke or heart attack

Table 2. Comparison of facility demographics.

	Group 1*	Group 2†	Group 3‡	Group 4§
N	67	84	36	26
Funding model				
Not for profit	14%	21%	17%	42%
For profit	55%	56%	42%	23%
Government sponsored	25%	23%	36%	27%
Missing	6%	0%	6%	8%
No. of clients currently enrolled				
Mean±SD	974±1268	1415±2383	2224±2661	1331±1927
Range	20–5200	16–13 164	10–10 000	9–8000
No. of responders	53	75	32	23
No. of full-time equivalent employees				
Mean±SD	7±11	18±39	20±40	15±17
Range	0–66	0–200	0–210	0–60
No. of responders	61	79	32	23
Facility area (square feet)				
Mean±SD	15 122±19 330	41 880±235 659	33 333±59 995	45 820±92 919
Range	750–80 840	100–2 000 000	800–250 000	500–300 000
No. of responders	45	72	24	10
Health care professionals				
Kinesiologist	14%	31%	36%	19%
Personal trainer	45%	27%	53%	42%
Recreation therapist	2%	5%	17%	31%
Athletic therapist	6%	12%	8%	15%
Occupational therapist	2%	2%	8%	15%
Physical therapist	3%	19%	19%	31%
Fitness instructor	17%	14%	17%	19%
Chiropractor	5%	7%	3%	4%
Massage therapist	9%	9%	8%	8%
Other	45%	45%	50%	50%

Note: There was a statistically significant difference differences between the 4 types of facilities in terms of the funding model ($p < 0.02$) and facility area ($p < 0.001$).
*Facilities that do not allow or are unaware if individuals with chronic disabilities participate in their programs.
†Facilities that allow individuals with chronic disabilities to participate.
‡Facilities with specific programs for individuals with chronic disabilities.
§Facilities with programs specific for individuals post-stroke.

Exercise on Prescription Schemes

(Disabil Rehab 2008; 30: 1966-1975)

Discussion and Recommendations

- Physiotherapists used service to facilitate discharge
- Concerns about knowledge of community instructors and equipment that was appropriate for someone with a disability
- Better to start in community facility before discharge
- Better liaisons – PT positions in leisure centres, ability to refer back

CICRP
June 2009, Volume 17, No.1
Current Issues in Cardiac Rehabilitation and Prevention

Integrating Individuals with Stroke into Cardiac Rehabilitation

Official publication of CACRC Canadian Association of Cardiac Rehabilitation

Exercise and Risk Factor Modification Following Stroke
Susan Marzolini, MSc, Ada Tang, MSc, Dina Brooks, PhD, Martha Strong, RN, Paul Oh, MD

Cardiac Rehabilitation After Stroke—Need and Opportunity

Ada Tang, MSc, Valerie Closson, MSc, Susan Marzolini, MSc, Paul Oh, MD, MSc, William McIlroy, PhD, and Dina Brooks, PhD

A pilot randomized controlled trial to evaluate the benefit of the cardiac rehabilitation paradigm for the non-acute ischaemic stroke population
Olive Lennon, Aisling Carey, Niamh Gaffney, Julia Stephenson and Catherine Blake
Clin Rehabil 2008; 22; 125
DOI: 10.1177/0269215507081580

TRI-REPS Program (Toronto Rehab)

- Inclusion
  - Three months post
  - Mild to moderate hemiparesis
  - Able to walk 10m independently (90% use walking aid)
  - No significant limitations due to pain
- Screening
  - Graded exercise test
  - Blood work
  - Blood pressure measured monthly

TRI-REPS Program (Toronto Rehab)

- Program Structure
  - ½ day intake and orientation
  - 90 minute classes, once weekly X 24 weeks, then one meeting per month X 2 months
  - 15 education sessions
  - Ratio 5 patients/one staff (compared to 10 to 1 for cardiac rehab)
  - Staff - kinesiologists

Chronic Disease Management

- Stroke is a chronic disease with acute events (BMJ, March 2008)
- http://www.cesnstroke.ca/chronic_DM.php
- Self management component
  - http://www.heartandstroke.ab.ca/site/c.lqIRL1PJJtH/b.3916701/k.56AE/Stroke__Living_with_Stroke_Program.htm

Changing Behaviour is Difficult!

- Repeated instructions and facilitation to increase physical activity doesn't change behaviour (ExStroke Trial; BMJ August 2009)

Evidence that more active interventions can lead to behaviour change

- PREPARE Program (Diabetes Care 32: 1404-1410; 2009)
  - 180 minute intervention
    - patient story, professional story, diet, physical activity (self efficacy, action plans, use of pedometer).
  - Follow-up – 10 minute review at 3 and 6 months
- Pedometer based telephone intervention with cardiac patients (Patient Educ Counsel 2009 Dec 16 epub)
  - Calls at 1, 3 & 6 weeks. Booster calls at 12 and 18 weeks.

Summary

- Interventions change outcomes such as endurance or aerobic capacity
- Minimal evidence that exercise or physical activity can reduce metabolic risk factors or recurrent stroke
- Gains are lost at follow-up
- Pattern of activity may be important
- New strategies needed!

Translating Evidence Into Practice: A Decade of Efforts by the American Heart Association/American Stroke Association to Reduce Death and Disability Due to Stroke

A Presidential Advisory From the American Heart Association/American Stroke Association

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- "The focus of the next decade will be to shift individuals and communities to states of ideal cardiovascular health" (Stroke 2010; 41:1051-1065)