The Effects of Aerobic Exercise on Functional Recovery Post Stroke As Defined by the ICF:
A Systematic Review

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Outline

- Background information on stroke, aerobic exercise, aerobic capacity and function
- Methods
- Results
- Discussion
- Review Limitations and research recommendations
- Clinical message
- Acknowledgements
Background
Stroke

- Stroke is the number one cause of long-term adult disability
- Total number of stroke survivors is increasing
- 60% of stroke survivors have residual motor impairments that may limit physical activity
- Deconditioning compromises physical independence and quality of life
- High risk of recurrent stroke and coronary artery disease
Aerobic Capacity

- Aerobic capacity is the body’s ability to deliver and utilize O$_2$
- Decreased physical activity severely decreases aerobic capacity
- Stroke survivors have a 30-40% lower aerobic capacity than age-matched individuals
Aerobic Capacity and Function

- Stroke survivors have to work at a higher relative intensity compared to individuals with a higher VO$_{2\text{max}}$ to complete the same functional tasks.

- Increased energy demands secondary to stroke related deficits.

- Low aerobic capacity + increased energy demands = decreased functional capacity.
Aerobic Exercise & Stroke

- Aerobic exercise training increases aerobic capacity in the stroke population
- Using a variety of exercise modalities
- Results → able to perform the same activities at a lower sub-max VO₂
- Aerobic exercise reduces secondary disease and decreases the risk of recurrent stroke
International Classification of Function, Disability and Health

- Provides a framework in which to categorize the collection of problems associated with stroke

- Includes three domains: Body Function and Structure, Activity and Participation
  
    - Impairments
    - Activity limitations
    - Participation restrictions
Research at the Impairment Level of the ICF

- A meta-analysis on the effects of aerobic exercise training on aerobic capacity in individuals with stroke

Conclusions:
- Aerobic exercise is effective at improving aerobic capacity in individuals with mild and moderate stroke
- Provides support that aerobic exercise leads to improved function at the Impairment level of the ICF
Research at the Activity and Participation levels of the ICF

- The effect physical therapy interventions on function post stroke, including aerobic exercise
  - No improvements in ADL’s or IADL’s

- Systematic review of exercise trials post stroke
  - Did not isolate aerobic exercise from functional exercise
  - Insufficient evidence to support cardiovascular interventions at increasing function
Rationale for the Review

- Aerobic exercise has shown to be effective at treating deficits at the *impairment* level.
- The effectiveness of aerobic exercise in increasing function at the *activity* and *participation* levels remains unclear.
- Important for clinicians to use literature supported treatment interventions.
- Taken together, a review of the relationship between aerobic exercise and function is warranted.
The objective of this systematic review is to determine if aerobic exercise improves function at the activity and participation levels of the ICF.

Provide clinicians with the evidence to achieve best practice.
Methods
Review question

- Does aerobic exercise improve functional ability in individuals recovering from stroke?
- Aerobic exercise defined by ACSM
  - 20 - 60 minutes
  - 3-5 days a week at 60% - 80% \( \text{HR}_{\text{max}} \) or 40% - 60% HRR
  - Minimum of 6 weeks
- Function defined by the ICF
Inclusion Criteria

- Clinical Trials on the effects of aerobic exercise training in individuals 19 years and older with stroke
- Met the ACSM guidelines for aerobic exercise, or explicitly stated the use of an aerobic exercise intervention
- English full-text version could be obtained
- At least one functional outcome measure
Exclusion Criteria

- Non peer-reviewed sources
- Studies with multiple exercise interventions in which aerobic exercise cannot be isolated
Literature Search

- MEDLINE, EMBASE, CINAHL, SPORTdiscus, Cochrane Library Database of Systematic Reviews, PEDro
- Completed in August 2007
- Articles screened at title, abstract and full text
- Completed by 2 independent reviewers (3rd reviewer for discrepancies)
- Reference lists of chosen articles were manually searched
- Web of Science to locate studies that referenced the chosen articles
Qualitative Assessment

- PEDro scale was used to evaluate each article by 2 independent reviewers (3rd reviewer for discrepancies)

- To assess the methodological quality of physical therapy RCT’s

- All included RCTs were ‘good’

- Grading
  - 9-10: excellent
  - 6-8: good
  - 4-5: fair
  - <4: poor
Quantitative analysis

- For each outcome measure the mean change scores were calculated.
- Baseline SD’s in the experimental and control groups were used to calculate the pooled population SD.
- Using RevMan, SES was calculated.
  - Cohen’s classification
    - Small: $d=0.2$
    - Medium: $d=0.5$
    - Large: $d=0.8$
- 95% CI calculated.
- Forest plots used for graphical representation.
Results
Article Selection

3133  Combined results following online database search
303   Assessed at abstract level
23    Retained for analysis at full text level
 18   Excluded from further review
   5   Retained

+1    Following Web of Science and manual search
   6   Studies based on 5 RCT’s
Subjects

- Number of subjects within each study ranged from 13-92
- Calculated mean age: ~ 63 years old
- Both sub-acute and chronic stroke survivors
- Stroke impairment levels ranged from mild to moderate
- Only 3 RCT’s identified stroke type
  - Ischemic, hemorrhagic
Exercise Training Protocol

As per ACSM Guidelines

- Cycle ergometer in conjunction with ‘regular’ physical therapy
- Treadmill training
- Treadmill training combined with Bobath therapy
- Water-based exercise (chest-deep water)

**Total intervention lengths:** 6 weeks, 8 weeks, 10 weeks, and 6 months
Outcome Measures:

**Activity Level**

- **WALKING VELOCITY:**
  - 10m walk, 8m walk, 30 foot self-paced walk

- **WALKING CAPACITY:**
  - 6 Minute Walk Test

- **BALANCE:**
  - Berg Balance Scale, component of Fugl-Meyer Assessment

- **FUNCTIONAL MOBILITY:**
  - Rivermead Mobility Index
  - Gross Motor subscale of Rivermead Motor Assessment Scale
Outcome Measures:

*Activity and Participation Levels*

- Frenchay Activity Index
- Functional Independence Measure
Effect of Treadmill Training

- 2 studies used 6MWT and walking velocity (Eich et al., Macko et al.)

- 6MWT:
  - Used as a measure of walking capacity
  - Significant effect sizes (ES) found in favor of the exercise group
  - large effects:
    - $d=0.89$ (Eich et al.)
    - $d=2.4$ (Macko et al.)
Results

- **Walking velocity:**
  - Only Eich et al. found significant effects
    - Large: $d = 0.98$
  - Macko et al. did not find significant effects
    - Trend toward favoring the exercise group
    - $d = 0.43; CI -0.08-0.94$

- **Rivermead Motor Assessment Scale (RMA):**
  - No significant effect found (Eich et al.)

- **Rivermead Mobility Index (RMI):**
  - Large significant effect size found (Macko et al.)
  - $d = 2.42$
Treadmill Training

Effect of Treadmill Training on Functional Outcomes

-3.5 -2.5 -1.5 -0.5 0.5 1.5 2.5 3.5

Standard Mean Difference

Favor Control Favor Experimental

RMA (Eich, 2004)
Walking Velocity (Macko, 2005)
Walking Velocity (Eich, 2004)
6MWT (Eich, 2004)
6MWT (Macko, 2005)
RMI (Macko, 2005)
Effects of Cycle Ergometer Training

- 2 studies used this mode of training (Katz-Leurer, Potempa)

- Outcome measures included the Functional independence measure (FIM), Frenchay Activities Index (FAI), and Fugl-Meyer Index

- No significant effect sizes were produced
Effect of Cycle Ergometer Training on Functional Outcomes

- Fugl-Meyer (Potempa)
- FIM (Katz-Leurer)
- FAI (Katz-Leurer)
Water-based aerobic exercise training

- One study used this mode of training (Chu et al.)
  - Measured the effects on balance and walking velocity
    - Balance (Berg Balance Score)
      - Significant effect size favoring the control group
        (d= 0.71)
    - Walking Velocity
      - No significant effect size found
Water based aerobic exercise

Effect of Water Based Aerobic Exercise on Functional Outcomes

- Walking Velocity, m/s (Chu et al., 2004)
- BBS (Chu et al., 2004)
Gait velocity can be divided into three functional ambulation categories:

- Household ambulation (<0.4 m/s)
- Limited community ambulation (0.4 to 0.8 m/s)
- Full community ambulation (>0.8 m/s)
Both Eich et al. and Macko et al. investigated walking capacity

- **Eich et al.**
  - All participants were at the level of household ambulation
  - Both groups progressed to limited community ambulation
  - Treatment group had statistically significant changes in walking velocity
  - No clinical significance was found between the two groups according to their ambulatory category
Ambulation Categories

- **Macko et al.**
  - Both treatment and control participants classified as limited community ambulators
  - Both did not progress to full community ambulation after study completion
  - Small improvements were seen within the category
  - These results were consistent regardless of distance

- **Chu et al.**
  - Treatment and control groups of study were at the level of full community ambulation at baseline
  - Remained in this category after treatment
**Body Structure/Function**

- no measures

**Activity**

*Walking Capacity (6MWT)*

- significantly improved with treadmill training

*Walking Velocity*

- mixed results according to two studies

*RMI*

- significantly improved by treadmill training according to one study

*RMA, FIM, Fugl-Meyer*

- No significant effect sizes produced with any mode of training

*Berg Balance Score*

- water based aerobic exercise does not help with balance

**Participation**

*FAI, Fugl-Meyer*

- no significant improvements with aerobic cycle ergometer training
Discussion
Treadmill Training

- Improved walking capacity, and demonstrated a trend toward improved velocity and functional mobility.

- Evidence supports task-specific treadmill training in improving walking speed and walking capacity.

- Capacity and velocity improvements could be due to:
  - practice specificity
  - changes in aerobic capacity.
RMI indicated improved functional mobility with AEX

Longer length intervention does not result in superior outcomes

In both studies statistically significant changes were found, did not result in clinically significant in ambulation category
Water based Exercise

- AEX showed a trend towards improved walking velocity
- All participants were considered full community ambulators at the onset of the study
- Therefore there may have been a ceiling effect
Cycle Ergometry

- Does not improve functional performance as measured by the Fugl-Meyer, FAI, and FIM scales
- FIM and Fugl-Meyer have a ceiling effect when used to assess those with mild to moderate stroke
- The FAI has poor test-retest reliability which may account for the lack of observed change
Review
Limitations and Research Recommendations
RCT Limitations

- Small sample size
- Participants tended to be healthier and less physically affected
- Studies lacked long term follow-up.
- Type of stroke varied among studies.
SR Limitations

- Only included studies utilizing the ACSM aerobic exercise guidelines
- Lower intensities may improve cardiovascular fitness in individuals with stroke
- ACSM aerobic exercise guidelines were not used or measured in a # or treadmill training studies and therefore were excluded
- Lastly, variability among control interventions may have impacted inter-group comparisons and thus the results of this review.
Future studies should use:

- Larger sample sizes
- Valid, reliable, and sensitive outcome measures that encompass all components of the ICF
- Less task-specific interventions to determine the relationship between aerobic exercise and functional recovery

Studies should also investigate whether ACSM guidelines are required to induce an aerobic training effect in the stroke population
Clinical Message

- Insufficient evidence to support aerobic exercise as a sole treatment intervention to enhance function.
- Aerobic exercise should remain one component of a comprehensive stroke rehabilitation program.
Conclusion

- Aerobic exercise does not appear to enhance functional parameters such as balance, or increase aspects of participation such as social outings, work, and hobbies as measured by FIM and FAI.
- Treadmill aerobic exercise increases walking capacity. The effects of treadmill aerobic exercise on functional mobility and velocity remain inconclusive, although a trend favoring the treatment group exists.
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References

1. Heart Disease and stroke statistics-2006 update. A report from the American heart association statistics committee and stroke statistic subcommittee. HOW TO REF THIS?
References


40. Ada L. A treadmill and overground walking program improves walking in persons residing in the community after stroke: a placebo-controlled, randomized trial. *Archives of physical medicine and rehabilitation* 2003;84(10):1486

