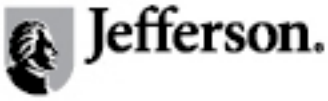

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Does high-intensity exercise better improve ambulation in the population with chronic stroke, as compared to standard care?: A Systematic Review of the Literature

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Does high-intensity exercise better improve ambulation in the population with chronic stroke, as compared to standard care?: A Systematic Review of the Literature

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Background

Each year approximately 15 million strokes occur worldwide, making strokes the leading cause of adult disability.[1] The prevalence of stroke is predicted to increase with the growth of the aging population, and as a result, the population of those living with disability post-stroke is expected to rise similarly.[2] Following a stroke, survivors' walking deficits often include decreased velocity, [3] alterations in walking mechanics,[3] and impairments in cardiovascular fitness.[4,5] Post-stroke walking deficits have been shown to have a profound impact on functional independence, and therefore are a major contributor to adult disability.[6]

Historically, physical therapy has been successful in the recovery of walking for this population. Previous studies suggest that physical therapists who utilize a combination of intensive mobility training, functional strengthening, balance exercises, aerobic training, and variable walking task training are generally successful with improving gait ability in the population with chronic stroke.[7] However, more recent research suggests that it is not only the type of training that is important to achieve maximal results, but also how the training is implemented. Much of the functional improvement that occurs with activity during physical therapy is in response to neuroplastic changes in the brain[8] and intensity of exercise has been shown to be of one of the key principles impacting the induction of neuroplastic changes.[9] This leads to the question; does high-intensity exercise have a greater impact on the recovery of walking than standard care in chronic stroke survivors?

Currently, there is a lack of evidence evaluating whether interventions performed at sufficient high-intensities in the population with chronic stroke have an effect on improving gait. Given that high-intensity exercise has been shown to induce neuroplastic changes, we hypothesize that high-intensity training will better facilitate neuroplasticity and result in greater improvements in gait than standard care.

Purpose

To assess the effectiveness of high-intensity exercise on the improvement of gait deficits in survivors of chronic stroke as compared to standard care.

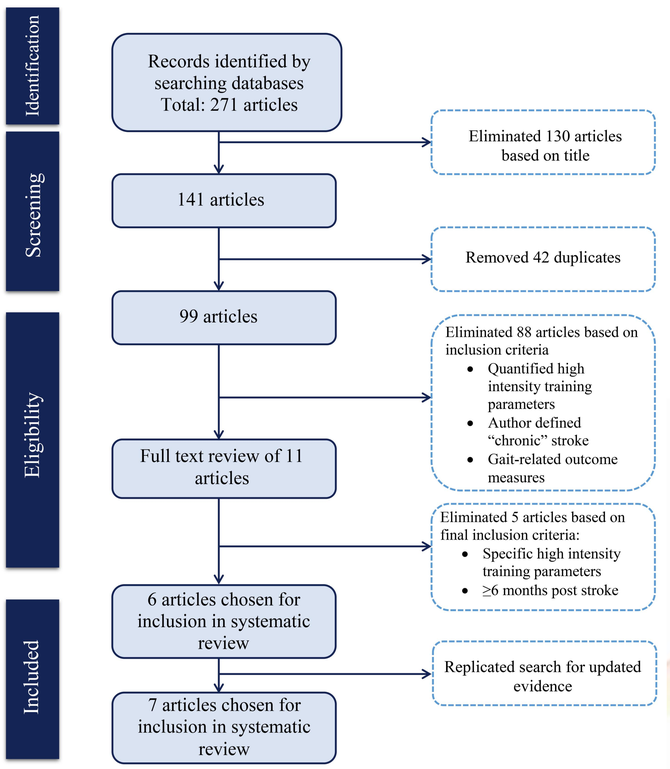
Methods

A literature search was conducted during July and September of 2015 (Figure 1). The databases searched were PubMed, Ovid, Cochrane, Scopus, and CINAHL. The search terms used were "high-intensity" AND "stroke" AND (walk OR gait). The search included the following limiters: English language, human participants, and publication in the last 10 years (2005-2015). The final inclusion criteria was as follows:

1. High-intensity as defined by ≥60% HRR, ≥60% max HRR, RPE scale ≥15, ≥85% HR_{peak}, ≥80 age predicted HR_{max}, ≥80% 1RM
2. ≥6 months post stroke
3. ≥1 gait-related outcome measure

Seven articles were chosen for final inclusion in this systematic review and were assessed for risk of bias using the PEDro scale.[10] The PEDro scale is used to weigh the varying quality of evidence from individual research articles with the intent to draw scientifically sound, clinical conclusions.[10]

Figure 1. Flow chart for the selection of studies



Results

Table 1. Description of Studies

Author	n	Mode of Exercise	Post-intervention Data Collected	Outcome Measures	Conclusions	PEDro Score
Gjellsevik et al., 2012	8	• Intervals of uphill treadmill walking • 5 days/week for 4 weeks	Immediately post intervention and at one year	VO_{2peak}, walking economy, 6MWT, 10MWT, TUG	High aerobic intensity interval treadmill walking significantly increased VO_{2peak} and improved C_w. The training was feasible and may have important implications for cardiovascular health and future rehabilitation programs.	3
Globas et al., 2012	36	• Treadmill training with no inclination vs. "conventional care physiotherapy" • Intervention group 3 days/week for 3 months • Control group 1-3 days/week for 3 months	Immediately post intervention and at one year	VO_{2peak}, 6MWT, 5CR, 10MWT, BBS, RMI, SF-12	Aerobic Treadmill Exercise (TAEX) effectively improves cardiovascular fitness and gait in persons with chronic stroke. TAEX effects were largely preserved one year after the intervention.	6
Holleran, et al., 2014	10	• Treadmill training, over-ground walking, stair climbing, and step training with perturbations • 5 days/week for 10 weeks	Immediately post intervention and at three months	6MWT, steps/day, SSS and FS over short distances, spatiotemporal symmetry of gait, feasibility	Suggested that stepping training at high intensities in variable contexts was tolerated by participants, with significant locomotor improvements. Future studies should delineate the relative contributions of amount, intensity, and variability of stepping training to maximize outcomes.	3
Holleran et al., 2015	12	• Treadmill and over-ground training with control for step practice • 12 or fewer sessions over 4-5 weeks	Immediately post intervention	SSV, FV, 6MWT, peak treadmill speed, gait economy, HR, VO_2	Provides the first evidence that intensity of locomotor practice may be an important determinant of walking outcomes post stroke. In the clinical setting, intensity of locomotor training can be manipulated in many ways, although this represents only one parameter to consider.	7
Ivey, et al., 2015	34	• High intensity treadmill training vs. low intensity treadmill training • 6 months	Immediately post intervention	VO_{2peak}, 6MWT, 30WT, 48-hour step counts	Demonstrated that added emphasis on high-intensity treadmill training progression is more effective at improving VO_{2peak} than low intensity treadmill training in chronic stroke population.	5
Moore, et al., 2009	20	• Treadmill training with body weight support • 2-5 days/week for 4 weeks	Immediately post intervention	SSV, FV, 12MWT, O2 cost, peak treadmill speed, VO_{2peak}, BBS, TUG	Intensive locomotor training results in improved daily stepping in individuals post stroke who have been discharged from PT because of a perceived plateau in motor function. These improvements may be related to the amount and intensity of stepping practice.	7
Severinson et al., 2014	43	• Cycle ergometer vs. progressive resistance training using machines vs. sham upper extremity resistance training • 3 days/week for 12 weeks	Immediately poster intervention and at one year	6MWT, 10MWT, walking velocity, VO_{2peak}, maximal isometric knee extension strength, MAS, Fugl-Meyer test, SF-36, PAS	Improvement of muscle strength or aerobic capacity using non-task-specific training methods does not result in improved ambulation in chronic stroke. Muscle strength gains were maintained at follow-up, whereas all improvements of aerobic capacity were lost, indicating a long lasting effect of intensive RT even without maintenance training.	8

Across the seven papers chosen for inclusion in this systematic review, high-intensity training was achieved in multiple ways: treadmill and over ground gait training (with and without body weight support), lower extremity cycle ergometry, and resistance training. The results of each intervention are reviewed below:

Six studies utilized high-intensity treadmill training as a means of high intensity intervention. All six of the studies utilized walking endurance outcome measures. The following results were found:

- All six studies reported significant improvements in walking endurance outcomes immediately post intervention[11,12,13,14,15,16]
- 2 of the three studies that included follow-up periods found retention of walking endurance improvements[13,15]

Five of the 6 studies utilized an aerobic outcome measure to measure changes in walking outcomes. The following results were found:

- 3 of the five studies measuring VO2 max or peak VO2 reported significant improvements immediately post intervention[11,13,14]
- Neither of the two studies which included follow-up periods demonstrated maintenance of improvements in aerobic capacity[13,14]

All six studies utilized gait speed as a walking outcome measure. The following results were found:

- 5 of the six studies reported significant improvements in gait speed immediately post intervention, while the sixth study reported a non-significant increase in gait speed[11,12,13,14,15,16]
- The three studies that included follow-up periods all reported maintenance of gait speed improvements[13,14,15]

One of the 6 studies analyzed change in gait mechanics. The following result was found:

- Significant increase in single leg stance on paretic leg and a non-significant trend for improvement in step-length symmetry immediately post intervention and at follow-up[15]

One study utilized high-intensity exercise without stepping as a means of high-intensity exercise (See Table 1).[17] The following results were found regarding walking endurance, aerobic capacity, and gait speed:

- Non-significant improvements in 6MWT in all groups, however none of the improvements were maintained at follow-up
- High-intensity cycling group reported significant peak VO_2 improvements immediately post intervention
- High intensity resistance training group and control group had non-significant improvements in peak VO_2 immediately post intervention, however none of the groups demonstrated maintenance of improvements at follow-up
- High-intensity cycling group reported non-significant improvements in walking speed immediately post intervention
- High-intensity resistance training group and control groups reported significant improvements in walking speed immediately post intervention, and these results were maintained at follow-up

Discussion

This review established positive findings supporting high-intensity as a feasible and effective means of improving walking outcome measures in the population with chronic stroke. In total, only one adverse event was reported. [15]

- Task specific walking interventions were found to better facilitate improvement in walking outcomes when compared to other modes of exercise. According to Kleim and Jones' research on the principles of neural plasticity, specificity of training facilitates the process of neuroplasticity.[8] The findings below support the idea that task-specific training better facilitates recovery of function than practicing other unrelated tasks.[18,19]
- Six articles utilized various high-intensity walking interventions and found either significance or trends for improvement in all outcome measures related to walking endurance, walking velocity and gait characteristics[11,12,13,14,15,16]
- One article utilized high-intensity cycling and resistance interventions, resulting in inconsistent findings across all gait-related outcome measures

Another principle of neuroplasticity, intensity of training,[8] was employed by all of the studies. Each study included in this review explicitly defined high-intensity within certain parameters. However, these parameters varied throughout the studies. Multiple of the included studies also used different means to increase the level of intensity of exercise. All variations of high-intensity walking interventions showed at least a trend toward improved walking outcome measures, supporting the importance of intensity as a principle of neuroplasticity.[8] However, the variety of approaches makes it difficult to comment on which, if any, method of increasing intensity is superior.

Multiple studies included in this review used the RPE scale rather than HR_{max} to determine high-intensity exercise for participants who were taking beta blockers. The effects of beta blockers prevent this group of participants from reaching the established high-intensity exercise parameter of 75-85% HR_{max}.[20] Therefore, the validity of the use of the RPE scale for participants on these medications can be questioned.

Some of the studies included in this review reported information about the activity performed during follow-up periods, while others did not. One study reported that some of the participants continued treadmill training during the follow-up period and demonstrated significantly better results on the 6MWT and a trend for better peak VO_2 and maximum walking speed than those who did not exercise during follow-up.[14] This suggests that continued exercise is necessary to maintain acquired gait improvements. This notion is further supported by multiple studies that suggest continued exercise training results in maintenance, and even improvement, in various walking outcome measures.[21,22,23]

Conclusion

- The results of this review suggest that high-intensity exercise is effective in improving ambulation in the population with chronic stroke; however, due to insufficient evidence, we cannot say with certainty that high-intensity exercise is superior to standard care at this time
- Results also suggest that walking-specific high-intensity exercise is superior to less task-specific high-intensity exercise
- The evidence suggests that continued exercise post rehabilitation is necessary in order to retain improvements

Clinical recommendations:

1. Physical therapists should consider the use of high-intensity walking interventions as an effective means of gait rehabilitation for persons with chronic stroke
2. Physical therapists should make recommendations for continuing walking exercise post rehabilitation

Future Research

In order to determine the superiority of high-intensity walking-specific exercise to other commonly used physical therapy interventions, future research should focus on the following:

- Direct comparison of high-intensity walking training and standard care in order to allow for a more definitive determination as to whether high-intensity is in fact a superior method of improving walking outcomes in survivors of chronic stroke
- Identifying specific dosage parameters for high-intensity walking interventions in order to potentially aid in the establishment of a standard of care for survivors of stroke that utilizes high-intensity walking training
- Solidifying the positive effects of continued training in this population by identifying if adherence to a structured exercise program can result in increased long-term effects on gait outcomes

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The seven articles included in this systematic review of the literature are as follows:

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Complete reference list available upon request.