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Integrating Aerobic and Musculoskeletal Training can Prevent the Vicious Cycle of Physical Inactivity and Functional Decline: Knowledge Translation of Clinical Exercise Rehabilitation for Stroke Survivors

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Abstract
To reduce the risk of cardiovascular disease and related comorbidities in chronic stroke survivors, clinical exercise rehabilitation has focused on improving their mobility, functional independence and overall physical activity experience. Evidence suggests that the integration of an aerobic and musculoskeletal training paradigm can provide reciprocal health benefits that can counter the vicious cycle of physical inactivity and functional decline in individuals who have had a mild-to-moderate stroke. The purpose of this review is to supplement an evidence-based knowledge translation video designed to educate the general public on the health-related benefits of physical activity post-stroke. **Health & Fitness Journal of Canada 2017;10(1):23-28.**

Keywords: Stroke, Aerobic Training, Musculoskeletal Fitness, Chronic Disease Management, Clinical Exercise Rehabilitation, Physical Activity, Health Promotion

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Introduction

A stroke is a medical emergency that occurs when blood supply to the brain is reduced, leading to oxygen deprivation and subsequent cellular death. In stroke survivors, neurological deficits and physical de-conditioning reduce mobility in parallel with functional status (Pang et al., 2012). Reductions in functional status can limit physical activity participation, which further undermines functional status. This vicious cycle of physical inactivity and functional decline increases secondary risk factors of cardiovascular disease and related comorbidities (e.g., hypertension, dyslipidemia, glucose metabolism, obesity and smoking), rendering stroke the most common disabling condition and third leading cause of death worldwide (Pang et al., 2006; Ontario Stroke Network). Statistics reveal that 1/3 of stroke survivors will experience a recurrent episode within 5 years, and that 50% of this population will have a lifespan of 8 years following a stroke (Ontario Stroke Network, 2016).

The association between increased risk of cardiovascular disease and related comorbidities following a stroke highlights the clinical importance of maintaining and/or improving mobility to enable physical activity participation. Evidence suggests that integrating aerobic-based training with musculoskeletal exercises can elicit reciprocal health-related benefits that can counter the cycle of physical inactivity and functional decline in stroke survivors (Pang et al., 2013; Stoller et al., 2012).

The primary purpose of this narrative review and commentary is to supplement an evidence-based knowledge translation video designed to educate the general public regarding the health-related benefits of physical activity after a stroke.

Key Findings

Traditional stroke rehabilitation programs emphasize muscle strengthening exercises to assist stroke survivors in regaining functional independence (Gordon et al., 2004). However, recent evidence has demonstrated the clinical importance of aerobic conditioning in addition to musculoskeletal fitness.

The health benefits of aerobic physical activity are well documented. Physical activity is a primary and secondary preventative strategy against chronic medical conditions that are secondary to stroke (Warburton et al., 2006). For instance, in a longitudinal study conducted by Lee and Blair (2002), 10 years of follow-up in 16,878 healthy men (between the ages of 40-87 years) revealed that highly active individuals conferred a 68% lower risk of stroke mortality in comparison to the least active individuals. Upon further analysis, it was revealed that the inverse relationship between aerobic fitness and stroke mortality remained even after adjusting for other factors of comorbidities. Consistent with the dose-response relationship between physical activity and health status, this finding provides support for the importance of aerobic conditioning in stroke survivors.

The evidence suggests that integrating aerobic exercises into musculoskeletal training paradigms can prevent secondary complications associated with physical inactivity, decrease recurrent strokes and cardiovascular events (which increase in prevalence following a stroke), as well as break the cycle of physical inactivity and functional decline (Gordon et al., 2004; Pang et al., 2013; Stoller et al., 2012).

In a systematic review of 25 trials, Pang et al. (2013) revealed that aerobic exercises can elicit marked aerobic benefits in stroke survivors. Based on their findings, there is strong evidence (grade A recommendation) to suggest that 20-40 min of aerobic exercise (3-5 days per week, 3 weeks to 6 months) performed at an intensity of 40-50% heart rate reserve (progressing to 60-80%) can significantly improve aerobic fitness, walking speed and walking endurance in risk-stratified individuals who have had a mild-to-moderate stroke. In fact, a meta-analysis revealed significant effect on these participants' peak oxygen consumption, peak workload, maximal gait speed and walking endurance (Pang et al., 2013). These observations suggest that risk-stratified chronic stroke survivors can benefit from individualized aerobic exercise prescription programs.

The findings by Pang and colleagues are consistent with earlier observations regarding the health-related benefits of aerobic training in chronic stroke survivors. These studies revealed that aerobic training programs can: 1) improve cardiorespiratory fitness in a manner that can enable stroke survivors to perform activities of daily living at a lower aerobic capacity (Macko et al., 2001); 2) increase their cardiorespiratory capacity by a magnitude that is similar to that of age-matched controls (Potempa et al., 1995); and 3) potentially elicit neuroplastic changes that may improve paretic leg muscle activation patterns to improve patterns of gait (Forrester et al., 2006). Collectively, the evidence reveals that aerobic conditioning can assist stroke survivors in breaking (and potentially reversing) the cycle of physical inactivity and functional decline.

By improving VO_2peak values above the functional threshold for dependence (14-17 mL/kg/min), not only do stroke survivors maintain their capacity to perform activities of daily living, but they also decrease their risk of fall-related injuries, which is more prevalent among older, functionally limited adults (Warburton et al., 2006). The latter remark is of clinical importance because fall-related injuries, such as hip and wrist fragility fractures, can lead to physical inactivity and the initiation of the vicious cycle. Preventing fragility fractures via musculoskeletal exercises is one approach to prevent physical inactivity in stroke survivors.

For these reasons, clinical exercise rehabilitation for stroke survivors should include both aerobic and musculoskeletal training (Ivey et al., 2006).

As highlighted by Gordon et al. (2004), incorporating resistance, neuromuscular and flexibility exercises can improve the conditioning response in aerobic exercises. For instance, completing 1-3 sets (10-15 repetitions) of 8-10 strength training exercises (e.g., isometric exercises and circuit training) can increase independence in activities of daily living. In particular, activities that focus on improving hand-grip strength can improve an individual's capacity to perform activities of daily living (Warburton et al., 2006).

Hand-grip strength is strongly correlated with functional status. It has been demonstrated that low hand-grip strength is associated with poor mobility and measures of lower extremity muscle power (Lauretani et al., 2003), as well as increased risk for developing disability and premature mortality (Rantanen, 2003; Sallinen et al., 2010). Because the wrist region is the second most common site of fragility fractures after a stroke (Dennis et al., 2002), fractures in the wrist can impair hand-grip strength, and by extension, an individual's capacity to perform activities of daily living. Hence, preventing wrist fractures is essential to maintaining physical activity participation in stroke survivors.

One method to improve hand-grip strength and prevent fragility fractures of the wrist is to prescribe resistance exercises that target the distal forearm region. It has been shown that the bone strength index of the distal radius epiphysis (the wrist end of the radius bone) can be reduced by up to 19% to 29% between 3 and 12 months following a stroke (Lazoura et al., 2008). Since muscle weakness is a primary indicator of bone strength in the hemiparetic distal radius epiphysis among chronic stroke patients (Pang et al., 2012), resistance exercises that target distal muscles of the arm can improve grip strength and reduce the risk of fragility fractures in this anatomical region.

As a supplementary to strength training, neuromuscular and flexibility exercises can prevent contractures and increase the range of motion of the affected extremities, both of which can contribute to increasing one's capacity to perform low-intensity physical activity (Gordon et al., 2004; Palmer-McLean and Harbst, 2003).

Based on the evidence, it is suggested that the gains associated with a musculoskeletal training paradigm can maintain and/or increase the functional threshold for dependence in chronic stroke survivors. The health benefits accrued in musculoskeletal exercises can lead to gains (e.g., improvements in strength and gait velocity) that can assist with performance in aerobic exercises such as treadmill training (Engardt et al., 1995; Sharp and Brouwer, 1997). Thus, musculoskeletal fitness can enable stroke survivors to improve their capacity for physical activity participation. While aerobic and musculoskeletal exercises provide unique health-related benefits, the reciprocal nature of these gains can break (and potentially reverse) the cycle of physical inactivity and functional decline commonly observed in chronic stroke survivors.

The evidence presented in this review highlights the clinical implications of aerobic conditioning in chronic stroke survivors. The recommendations made by Pang et al. (2013) target risk-stratified individuals who have had a mild-to-moderate stroke. Despite their recommendations for an individualized aerobic exercise prescription program for stroke survivors, it is important for all individuals to complete the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and (if necessary) the related electronic Physical Activity Readiness Medical Examination (ePARmed-X+; www.eparmedx.com), as these surveys are designed to assess an individual's risks for exercise-related adverse events (Bredin et al., 2013). Because the vicious cycle of physical inactivity and functional decline increases secondary risk factors of cardiovascular disease and related comorbidities, stroke survivors living with chronic diseases are often screened out of physical activity; however, because the PAR-Q+ and ePARmed-X+ allow for the risk stratification of various chronic conditions, individuals who are normally screened out of physical activity are now able to be screened back into exercise (Bredin et al., 2013).

Conclusion

The evidence supports the prescription of individualized aerobic and musculoskeletal training paradigms for risk-stratified stroke survivors. While aerobic conditioning has been shown to elicit improvements in aerobic fitness and several measures of gait, the gains accrued in musculoskeletal fitness programs can further improve an individual's capacity to perform physical activity. Thus, integrating aerobic and musculoskeletal training has the potential to break the cycle of physical inactivity and functional decline in chronic stroke survivors. Nevertheless, it is recommended that all individuals complete the PAR-Q+ and (if necessary) the ePARmed-X+ to ensure that they are appropriately screened for exercise-related adverse events.

Authors' Qualifications

The authors' qualifications are as follows: Henry Lai, BSc, BKIN; Phillip Do, BKIN; Darren Warburton, MSc, PhD, HFFC-CEP.

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