AEROBICS
2019 UPDATE

Aerobic
Exercise
Recommendations to
Optimize
Best practice
In
Care after
Stroke

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AEROBIC EXERCISE RECOMMENDATIONS TO OPTIMIZE BEST PRACTICES IN CARE AFTER STROKE: AEROBICS 2019 UPDATE

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ACKNOWLEDGEMENTS

We extend our gratitude to the consensus panel for their dedication, expertise and time dedicated to the AEROBICS program (Table 1). We also gratefully acknowledge **Emily Nguyen**, a research fellow from Trinity College Dublin, for her assistance in preparing the AEROBICS 2019 update.

Table 1. AEROBICS Consensus Panel Members

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EDITORIAL INDEPENDENCE

The AEROBICS project has not been influenced by views of the funding bodies. None of the Consensus Panel members disclosed competing interests. Input was based on their individual expertise and experiences; it did not represent formal endorsement by the institution of employment.

BACKGROUND AND METHODS

Introduction

The majority of stroke survivors have very low levels of cardiovascular fitness. It follows that survivors are limited in their ability to perform activities of daily living, which, over time, leads to further physical deconditioning and sedentary lifestyles. Greater reductions in fitness levels ensue that can worsen disability and increase recurrent stroke risk. Aerobic exercise can break this relentless cycle by increasing aerobic capacity, reducing the risk of co-morbidities, and enhancing the quality of life of stroke survivors.

Current clinical guidelines recommend that cardiovascular fitness training be a part of routine stroke rehabilitation and long-term management. As well, standards set by the stroke specialty panel of the Commission for Accreditation of Rehabilitation Facilities (CARF) endorse prevention of physical inactivity and physical deconditioning as important components of best care. However, specific screening and exercise prescription protocols are lacking in these guidelines, with the risk of limiting implementation of the recommendations. Some clinicians remain reticent to include fitness training for individuals post-stroke, partly because they lack safe, effective screening and exercise prescription protocols to guide clinical decision-making. Unfortunately, this lack of clear direction means that individuals post-stroke may be deprived of an intervention with demonstrated potency to restore and maintain physical and mental functions. In addition, exercise has been shown to reduce vascular risk factors and enhance secondary prevention in patients with coronary heart disease, a population who shares common risk factors and pathophysiology with patients post-stroke or transient ischemic attack (TIA). To "reach" clinicians, we must incorporate current best evidence from stroke and cardiac rehabilitation and secondary prevention research into a concise clinical protocol designed to enhance cardiovascular fitness training post-stroke.

Purpose, Scope and Target Audiences

The main purpose of the **A**erobic **E**xercise **R**ecommendations to **O**ptimize **B**est Practices **I**n **C**are after **S**troke (**AEROBICS**) project is to consolidate what is known about aerobic exercise for people after stroke or TIA into a user-friendly set of recommendations for clinicians. The ultimate objective is to promote implementation of aerobic exercise interventions after a cerebrovascular event through knowledge translation and professional development of health care professionals involved in stroke care. Clinical implementation of the recommendations will help not only to narrow the gap between evidence and practice but also to reduce current variability and uncertainty regarding the role of aerobic exercise in stroke rehabilitation.

The recommendations are supported by the highest quality of evidence available relevant to the utilization of aerobic exercise interventions in stroke management across stroke severity (i.e., TIA, non-disabling, moderate, and severe) and stages of recovery (i.e., rehabilitation, community reintegration, and long-term adaptation).

The principal target audiences for the recommendations are health professionals who are involved in care of adults post-stroke and TIA from early rehabilitation to home and community as well as health administrators and managers responsible for the coordination and delivery of services.

Development of AEROBICS 2013

The development of AEROBICS 2013 was undertaken between 2011-13 by an international group of stroke rehabilitation experts.[1] The process was guided by the Appraisal of Guidelines Research and Evaluation II Consortium[2] who identified 6 domains in recommendation development: (i) scope and purpose of the recommendations, (ii) stakeholder involvement, (iii) rigor of development, (iv) clarity and presentation, (v) applicability, and (vi) editorial independence. An iterative and pragmatic approach was used in developing the recommendations — proposing clinically feasible responses to clinically meaningful questions, with vetting by the consensus panel, external reviewers, and stroke survivors (Appendix 1). The final document consisted of 18 recommendations (7 about screening for safe participation and 11 about prescribing aerobic exercise) as well as supporting material for each recommendation (underlying rationale, system implications, performance measures, and summary of evidence).

AEROBICS 2019 Update

Clinical practice and evidence relevant to stroke rehabilitation and recovery are constantly evolving. Early in the processing of developing the original AEROBICS document, the importance of periodic review and revision of the AEROBICS recommendations was emphasized. The first step was to conduct a comprehensive review of the literature on issues related to AE post-stroke: physiological and functional benefits, indications and contraindications for aerobic exercise stress testing and interventions after stroke, as well as considerations regarding implementation across stroke severity and continuum of care. Several databases were searched — PubMed, CINAHL, PEDro, Cochrane Central Register of Controlled Trials — for relevant articles from 2012-18. To assess the rigor of individual interventional studies, levels of evidence (LOE) were assigned (Table 2).[3]

Table 2. Levels of Evidence of a Single Intervention Study[3]

LOE	Source of Evidence	Description
1	• Systematic reviews of randomized controlled trials (RCTs) • Large RCTs (n>100)	Yield strongest, most definitive evidence
2	• Smaller RCTs (n<100) • Systematic reviews of cohort studies • “Outcomes research” (very large ecologic studies)	Produce tentative conclusions
3	• Cohort studies (with concurrent control group) • Systematic reviews of case control studies	Suggest relationships but no conclusions regarding causation
4	• Case-series • Cohort study (with historical, not concurrent control group) • Case-Control Study	
5	• Expert opinion • Case study or report • Bench research • Expert opinion based on theory or physiologic research • Common sense or anecdotes	Do not permit drawing conclusions regarding treatment efficacy

Based on the review of the literature, the AEROBICS 2019 Update Working Group drafted revisions to the original AEROBICS document and determined level of evidence supporting each recommendation using the classification developed by Guyatt et al. (Table 3).[4] An iterative process was used to achieve consensus among members of the AEROBICS Consensus Panel. Final revisions included: (i) addition of 115 references to replace or augment those in the original AEROBICS document, (ii) rewording of several of the original recommendations and supporting material, and (iii) addition of two new recommendations regarding prescription (2.11 and 2.12).

Table 3. Level of Evidence Assigned to Each of the Recommendations[4]

Level of evidence	Description
A	Evidence from RCTs or meta-analyses of RCTs.
B	Single RCT or well-designed observational study with strong evidence; or well-designed cohort or case-control analytic study; or multiple time series or dramatic results of uncontrolled experiment.
C	At least one well-designed, non-experimental descriptive study (e.g., comparative studies, correlation studies, case studies) or expert committee reports, opinions and/or experience of respected authorities, including consensus from development and/or reviewer groups.

In the AEROBICS 2019 Update an "A" LOE was assigned to 3 screening and 2 prescription recommendations, "B" LOE to 1 screening and 8 prescription recommendations, and a "C" LOE to 3 screening and 3 prescription recommendations.

Operational Definitions

For the purposes of this project, the following terms were defined for consistency of interpretation:
Aerobic exercise (aerobic or cardiovascular training): Planned, structured, repetitive, physical activity performed for extended time periods at sufficient intensity to improve or maintain fitness.
Continuum of stroke care: Integrated system of care for individuals post-stroke from stroke onset to long-term adaptation and community integration or assisted-living. Stages of stroke with approximate time frames are: *hyperacute* (0-24 hours), *acute* (1-7 days), *early subacute* (7 days to 3 months), *late subacute* (3 to 6 months), *chronic* (> 6 months)[5]
Exercise stress test: Evaluation of physiological responses to exercise under controlled conditions with continuous ECG monitoring and frequent blood pressure measurement.
Heart rate reserve: Difference between maximal and resting heart rate
Physical activity: Bodily movement produced by skeletal muscle contraction that substantially increases energy expenditure, either in brief bursts of low to high intensity or long, sustained periods of lower intensity, depending on the type of activity and fitness level.[6]
Pre-participation screening: Evaluation of readiness for safe participation in aerobic training through assessment of medical contraindications and risk of exercise-related adverse events.

Abbreviations

6MWT – Six-Minute Walk Test
ACSM – American College of Sports Medicine
AEROBICS - Aerobic Exercise Recommendations to Optimize Best Practices In Care after Stroke
AF – atrial fibrillation
DM - diabetes mellitus
DBP – diastolic blood pressure
ECG - electrocardiogram
HIIT - high intensity interval training
HRmax – maximum heart rate
HRrest – resting heart rate
HRR – heart rate reserve
LOE – level of evidence
PARmed-X - Physical Activity Readiness Medical Examination
RCT - randomized controlled trials
RPE – rating of perceived exertion
SBP – systolic blood pressure
TIA – transient ischemic attack
VO_2 – oxygen consumption
VO_{2max} – maximum oxygen consumption
VO_{2peak} – peak oxygen consumption

AEROBIC RECOMMENDATIONS AT A GLANCE

SECTION 1. PRE-PARTICIPATION SCREENING FOR AEROBIC TRAINING AFTER STROKE OR TIA

1.1 *Who should be screened for possible participation in aerobic training after stroke or TIA?*

All patients following a cerebrovascular event (stroke or TIA) should be considered for potential participation in aerobic exercise interventions.

1.2 *When should an individual post-stroke or TIA be screened for possible participation in aerobic training?*

Screening for aerobic training should be initiated after a cerebrovascular event (stroke or TIA) when the patient is medically stable. To ensure continuity of appropriate interventions, screening should be repeated at transition points along the continuum of care based on changing neuromotor and cardiopulmonary capacities to participate in aerobic training

1.3 *Who should determine if an individual post-stroke or TIA is ready to begin aerobic training?*

Pre-participation evaluation for aerobic training after stroke or TIA should be provided by appropriately qualified health care professionals, consistent with their scope of practice and practice setting.

1.4 *What information is needed to determine if an individual post-stroke or TIA is ready to begin aerobic training?*

Before engaging in aerobic training, all individuals post-stroke or TIA must undergo a screening assessment to identify medical conditions that require special consideration or constitute a contraindication to exercise. Information to support screening should include:

i. General information: demographics, medical history, medications, cardiac history, seizure history, diabetes control, lifestyle habits,
ii. Assessment of contraindications to exercise testing and training,
iii. Evaluation of motor function, mobility, balance, swallowing, cognition (ability to follow simple instructions), and communication (verbal and non-verbal comprehension, ability to express pain or distress).

1.5 *When is an exercise stress test indicated in pre-participation screening for aerobic training after stroke or TIA?*

Whenever feasible, a symptom-limited or submaximal exercise stress test should be a component of pre-participation screening for aerobic training after stroke or TIA. However, if the planned aerobic intervention is to be conducted at the lower end of exercise intensities (for example, <50% of predicted heart rate reserve), a submaximal exercise test may be an option.

1.6 *How should exercise testing, as a component of the pre-participation screen for aerobic training after stroke or TIA, be conducted?*

Symptom-limited or submaximal stress tests should involve an adequate warm-up and cool-down and be administered by appropriately trained and experienced health care professionals with direct access to physician support and an external defibrillator. The participant should be on usual medications, avoid any strenuous activity for 24 hours prior to testing, and avoid a heavy meal, caffeine, or nicotine within 2 to 3 hours of testing.

Submaximal exercise tests involve walking, stepping, or cycling at a workload consistent with the planned intensity of the training program. Alternatively, submaximal field tests (e.g., Six-Minute Walk Test or Shuttle Walk Test) can be used.

1.7 *What should be monitored during a screening exercise test?*

During screening exercise tests clinical signs and symptoms, heart rate, blood pressure, and rating of perceived exertion should be monitored before, during, and after termination of the test until baseline values have been approximated. If an exercise stress test is used, continuous monitoring of electrocardiography (heart rate, electrical activity) should also be conducted.

SECTION 2. PRESCRIPTION OF AEROBIC EXERCISE INTERVENTIONS AFTER STROKE OR TIA

2.1 *How does aerobic training fit into the overall program of stroke rehabilitation?*
Aerobic training should be incorporated into a comprehensive, inter-professional program of stroke rehabilitation, vascular risk reduction, and secondary stroke prevention. Aerobic training should be implemented as part of an overall exercise program that may also include, but is not limited to, muscle strengthening and task-oriented training of motor control, balance, gait, and functional use of the upper extremity. Physical activity designed to maintain cardiovascular fitness is an important aspect of community reintegration after stroke.

2.2 *Where should aerobic exercise interventions be conducted?*
Aerobic exercise programs can be administered in a variety of barrier-free and accessible settings: hospital, outpatient clinics, community, and home. Training of high-risk individuals must be done in a setting with immediate access to external defibrillation and emergency medical response. For lower-risk individuals, supervised home-based aerobic exercise programs may be a safe and effective option.

2.3 *Who should design and supervise the aerobic exercise intervention?*
An aerobic exercise program for a person post-stroke should be designed by an appropriately qualified health care professional. The level of supervision of the participant is determined by the health care professional based on the individual participant's health condition. High-risk individuals require constant supervision, whereas low-risk individuals with demonstrated ability to exercise safely and effectively may require only intermittent supervision. Supervision may be provided by the qualified health care professional or an exercise instructor who has been trained by the health care professional.

2.4 *What format (individual, group) should be used for aerobic training?*
Aerobic exercise interventions can be conducted in either an individual (one-on-one) or group format, with the ratio of participant to supervising personnel determined by the severity of the participant's neurological and cardiac status, as well as the planned exercise intensity and mode of training.

2.5 *What mode of exercise should be used for aerobic training?*
Any mode of exercise that activates a large muscle mass for a prolonged period can be used to induce an aerobic training effect.

2.6 *How long should an aerobic training program be conducted?*
A minimum of 8 weeks of aerobic exercise is recommended to achieve a clinically meaningful training effect. However, physical activity should be sustained indefinitely to maintain health benefits.

2.7 *How frequently should aerobic training sessions be conducted?*
Structured aerobic exercise should be conducted a minimum of 3 days/week. On the other days of the week, participants are encouraged to engage in lighter forms of physical activity.

2.8 *How long should each aerobic training session last?*
Aerobic exercise sessions of ≥20 minutes are recommended, depending on exercise frequency and intensity. In addition, warm up and cool down periods of 3-5 minutes are advised. A gradual progression in the duration may be required, starting with bouts of 5 minutes or less and intervals of rest or lower-intensity exercise.

***2.9** What intensity of aerobic exercise should be used?*

Intensity of aerobic exercise must be determined on an individual basis, depending on response to the exercise stress test, health status (neurologic status, cardiac and other co-morbidities), and planned exercise frequency and duration. Percentage of heart rate reserve (HRR) is usually used to establish the target training intensity but other markers of intensity, such as rating of perceived exertion (RPE), can be used, particularly when heart rate is compromised by medication.

Light intensity: <40% HRR; <64% HRmax; RPE_{0-10} <4 or RPE_{6-20} <12
Moderate intensity: 40-60% HRR; 64-76% HRmax; RPE_{0-10} 4-5 or RPE_{6-20} 12-13
Vigorous exercise: >60% HRR; >76% HRmax; $RPE_{0-10} \geq 6$ or $RPE_{6-20} \geq 14$

***2.10** What should be monitored during aerobic exercise training?*

On-going observation of the general response to exercise, frequent heart rate monitoring, and periodic blood pressure and rating of perceived exertion monitoring are recommended for safety purposes and assurance that the participant is exercising at the planned intensity.

***2.11** How should the aerobic exercise program be progressed during a training program?*

Aerobic exercise should be progressed on an individual basis, with gradual progression of frequency, duration and intensity to minimize muscle soreness, fatigue, and injury. Duration should be increased by 5-10 minutes every 1-2 weeks for the first 4-6 weeks and intensity by 5-10% of heart rate reserve every 1-4 weeks, depending on fitness, health status, training responses, and exercise goals. Changes in blood pressure, heart rate, and rating of perceived exertion in response to the increased exercise dose should be monitored.

***2.12** What clinical outcome measures should be used to monitor effects of aerobic training?*

Outcomes aligned with participant-oriented goals and anticipated benefits of the training program should be assessed periodically to monitor change over time, progress the intervention, and transition to other settings or physical activities. The assessment should include measures of cardiovascular endurance/functional capacity (e.g., 6-minute walk test, shuttle walk test, heart rate at a fixed submaximal workload, daily step counts), cardiovascular health (e.g., blood pressure, blood lipids, fasting plasma glucose, waist circumference, medication adherence, tobacco use), and other relevant health domains (e.g., goal attainment, emotional well-being, exercise self-efficacy, quality of sleep, quality of life).

***2.13** What strategies can be used to encourage long-term participant engagement in aerobic training after stroke or TIA?*

An individualized plan, endorsed by the health care team, should be implemented to gradually transition from structured, clinical aerobic training to less structured, more self-directed physical activity at home or in the community. Multiple strategies should be used to deal with specific barriers related to health care providers, the environment, and the participant.

AEROBICS RECOMMENDATIONS

SECTION 1. PRE-PARTICIPATION SCREENING FOR AEROBIC TRAINING AFTER STROKE OR TIA

Best Practice Recommendation 1.1

Who should be screened for possible participation in aerobic training after stroke or TIA?

All patients following a cerebrovascular event (stroke or TIA) should be considered for potential participation in aerobic exercise interventions.

Level of Evidence: A (Several RCTs have demonstrated a broad range of benefits of aerobic exercise after stroke and TIA.)

Rationale

Given the wide range of known and potential benefits of aerobic exercise for individuals post-stroke (Box 1.1), little justification exists for not incorporating aerobic exercise interventions into the care of the majority of cases. Physical inactivity is an independent risk factor for vascular disease, including stroke.[7] Physical impairments (e.g., muscle weakness, impaired balance, changes in muscle tone) associated with stroke further restrict mobility and physical activity. In addition, the majority of individuals post-stroke also present with co-morbidities (e.g., hypertension, diabetes mellitus [DM]). Physical inactivity compounds secondary body composition abnormalities (e.g., hemiparetic muscle atrophy, increased intramuscular area fat, and shift to fast twitch muscle phenotype), increases fatigue, decreases oxidative capacity and increases insulin resistance.[8-11] These abnormalities are linked to high prevalence (~75%) of impaired glucose tolerance and DM in stroke survivors, conditions that prospectively predict two and threefold recurrent stroke risk, respectively.[12] Aerobic exercise has been shown to improve indices of insulin sensitivity, reversing impaired glucose tolerance and type-2 DM in nearly two-thirds of stroke cases.[13] As well, there is emerging evidence that comprehensive cardiac rehabilitation administered early after TIA or mild non-disabling stroke is feasible and effective in improving exercise capacity and cardiovascular risk factor profile.[14,15]

System Implications

- Routine pre-participation screening protocols for aerobic exercise interventions must be established.
- Screening and subsequent prescription of regular exercise needs to be considered as a component of secondary stroke prevention.

Performance Measures

- Percentage of individuals after stroke or TIA who are screened for aerobic exercise interventions.

Measurement Notes

Data gathering regarding screening for aerobic exercise interventions requires a chart review or consistent use of reliable workload measurement tools.

Summary of the Evidence

Age, gender, and stroke severity are among the factors to consider with respect to appropriateness of participating in aerobic exercise post-stroke. Although the effects of age and gender on response to aerobic exercise have not been systematically investigated in the stroke population, neither has been found to influence trainability in the non-disabled population[16] (LOE: 3). The position of the American College of Sports Medicine (ACSM) is that age should not be considered a barrier to exercise because improvements can be achieved across the lifespan.[17] Very few adverse events have been reported in post-stroke training studies, most of which have involved participants with an age range of 60-70 years.[18-28] An upper age limit was not an exclusion criterion in any of these studies. Thus, it is assumed that men and women of any age post-stroke are likely to benefit from aerobic exercise interventions.

In terms of stroke severity, most post-stroke exercise training studies involved people with mild to moderate stroke.[19,20,23,25,27,29-35] The feasibility, safety, and effectiveness of a program of adapted rehabilitation was demonstrated in a single cohort of 100 patients after recent non-disabling stroke or TIA with a high prevalence of the following modifiable vascular risk factors: sedentary lifestyle (61%), dyslipidemia (74%), hypertension (70%), DM (22%), obesity or excess weight (80%), and smoking history (70%) (LOE: 4).[14] Consistent with the excellent safety record of cardiac rehabilitation,[36] no adverse events were associated with treatment, and significant intake-to-exit changes were reported for exercise capacity (+31.4%; p<0.001), total cholesterol (-0.30 mmol/L; p=0.008), and TC/HDL ratio (-11.6%; p<0.001).[14] Katz-Leurer et al.[27] included people with more severe impairment in a trial of early aerobic training in subacute stroke survivors (LOE: 2). At the end of the program, significant differences were found in the exercise stress test time between groups stratified by stroke severity, and regardless of stroke severity, significant improvements were reported in step climbing.[27] Another study by Katz-Leurer and colleagues[37] (LOE: 2), investigating patients in the subacute stage of stroke with severity ranging from mild to severe, reported no adverse events during an aerobic exercise training program. A small, single-cohort study provided preliminary evidence that patients post-stroke in a neurointensive care unit could safely participate in a single session of 20 minutes of bedside leg ergometer exercise (LOE: 4).[38] There is also evidence that people with severely impaired non-diabetic stroke and abnormal glucose tolerance can benefit from low intensity cycle ergometry (LOE=2).[39,40] The findings of these studies suggest that aerobic exercise may be implemented safely across the spectrum of stroke severity. However, in terms of safety across the stages of stroke recovery, further investigation of the acute period post-stroke is warranted.

Box 1.1 Potential benefits of aerobic training post-stroke

The following is a list of potential benefits for which there is evidence in the stroke population.

Vascular risk reduction (Overall LOE: B)

Blood pressure

- Reduction in SBP at a fixed submaximal workload - LOE: 2[41]
- Reductions in resting SBP - LOE: 1,[42,43,44] LOE: 2[35] and resting DBP: LOE:1,[43] LOE: 3[21]

Lipid profile

- Improved total cholesterol - LOE:1;[43,44] total cholesterol, total cholesterol/high-density lipoprotein ratio - LOE:4[14]
- Improved total cholesterol and low-density lipoprotein cholesterol - LOE: 3[21]
- Improved high-density lipoprotein cholesterol - LOE: 1,[42,44] LOE: 4[45]

Insulin sensitivity

- Reduced insulin secretion - LOE: 3[20,44]
- Reduced fasting glucose - LOE: 1;[42,44] 3-hour insulin response: LOE: 2[46]
- Reversal of impaired glucose tolerance and type-2 DM, based on oral glucose tolerance test - LOE: 2[46]
- Improved fasting insulin - LOE: 1;[42] glucose tolerance: LOE: 2[39,40]

Systemic and cerebrovascular hemodynamics

- Improved femoral artery hemodynamics - LOE: 4[47]
- Improved bilateral lower extremity vasomotor reactivity - LOE: 2[48]
- Improved endogenous fibrinolysis profiles - LOE: 4[49]
- Improved cerebral blood flow - LOE: 2[50]
- Decreased arterial stiffness - LOE: 2[15,51,52]

Cardiac function

- Improved left ventricular contractility for individuals with coronary artery disease - LOE: 3[45]
- Reduced resting heart rate - LOE: 1[53]

Exercise capacity and energy expenditure (Overall LOE: A)

- Improved peak oxygen consumption: General stroke population – LOE: 1;[54] Subacute stroke –LOE: 1,[55] LOE: 2;[19,56] Chronic stroke - LOE: 2,[28,41,57] LOE: 3[58]
- Decreased steady-state oxygen consumption at submaximal workload: LOE: 2[57]
- Improved maximal workload - LOE: 2[27]
- Decreased energy expenditure of walking - LOE: 4[29,59,60]
- Reduced fatigue - LOE: 2[61,62]

Muscle strength and motor function of hemiparetic extremities (Overall LOE: B)

- Improved eccentric torque of hamstring musculature - LOE: 4[63]
- Higher composite lower extremity strength – LOE - 1,[64] LOE: 2[28,18]
- Higher composite muscle strength of upper and lower extremities - LOE: 5[65]
- Improvements in lower-extremity Fugl-Meyer scores - LOE: 2[25]

Balance and mobility (Overall LOE: A)

- Improved balance - LOE: 1,[19,66] LOE: 2,[25,67,68] LOE: 3,[20] LOE: 4[26,69,70]
- Enhanced gait pattern - LOE: 4,[71] LOE: 5[65]
- Increased walking speed - LOE: 1,[72,73] LOE: 2,[18,19,28,51] LOE: 4,[26,74] LOE: 5[24]
- Increased walking endurance - LOE: 1,[53,55,72,73,75] LOE: 2,[19,25,56,57] LOE: 3,[20,23] LOE: 4,[26,74] LOE: 5[24]

Cognition (Overall LOE: B)

- Reduced response time on serial reaction and repeated sequence tasks of non-affected hand - LOE: 2[76]
- Improved global cognitive ability - LOE: 1,[77] LOE: 2[50]
- Improved memory, attention, visual spatial ability - LOE: 1[78]
- Improved selective attention, conflict resolution, working memory, functional capacity - LOE 4[79]
- Improved information processing speed and implicit memory - LOE 2,[76] LOE 3[80]

Conflicting evidence: RCT found no effects on cognition - LOE 2[81]

Emotional and mental well being (Overall LOE: B)

- Reduced depressive symptoms - LOE: 1,[82,83] LOE: 2,[84,85] LOE: 3[20]
- Improved psychosocial health, perceived health and well-being - LOE: 2[53,61]
- Reduced mental health distress - LOE: 2[86,87]

Quality of life (Overall LOE: C)

- Improved overall health-related quality of life - LOE: 1,[88] LOE: 2[68]
- Enhanced performance satisfaction regarding activities of daily living - LOE: 4[26]

Conflicting evidence: Systematic review reported effect on quality of life remains inconclusive - LOE 1[72]

Employment status (Overall LOE: C)

- Relationship found between level of physical fitness post-stroke and return to fulltime employment - LOE: 4[89]

Bone Health (Overall LOE: C)

- Increased bone mineral density and bone geometry - LOE: 2[90]

LOE, level of evidence

Best Practice Recommendation 1.2

When should an individual post-stroke or TIA be screened for possible participation in aerobic training?

Screening for aerobic training should be initiated after onset of a cerebrovascular event (stroke or TIA) when the patient is medically stable. To ensure continuity of appropriate interventions, screening should be repeated at transition points along the continuum of care based on changing neuromotor and cardiopulmonary capacities to participate in aerobic training.

Level of evidence: B (Several RCTs have demonstrated safe and effective application of aerobic exercise interventions early after stroke. However, the level of evidence was downgraded due to lack of trials comparing aerobic training initiated early versus late after stroke or TIA.)

Rationale

Given the wide-ranging benefits that aerobic exercise may offer to individuals post-stroke or TIA (see Box 1.1), there are no compelling reasons to delay screening for participation in aerobic training once the individual is medically stable. Further, since exercise confers health benefits even years after stroke, aerobic training can be introduced regardless of how much time has elapsed since the original stroke event.

System Implications

- Education of health care providers regarding the need for screening and reassessment for aerobic exercise interventions at various points along the continuum of stroke care

Performance Measures

- Time from point of medical stability following stroke or TIA to initiation of pre-participation screening and implementation of aerobic exercise interventions, if appropriate.
- Percentage of persons post-stroke or TIA who undergo screening for aerobic training at transition points along the continuum of stroke care - inpatient rehabilitation, outpatient and ambulatory clinics (including secondary stroke prevention clinics), discharge to the community.

Summary of the Evidence

As a consequence of spending as much as 45% of the day resting in bed (LOE: 4),[91] patients in the early post-stroke period are at risk of the rapid decreases in aerobic capacity documented in non-disabled populations (LOE: 4).[92,93] Formal exercise testing using open circuit spirometry reveals that cardiovascular fitness levels of approximately 50% of age- and gender-matched sedentary controls[41,59,94] (LOE: 3) and that fitness levels improve minimally in the 1-6 month interval post-stroke stroke (LOE: 4).[95] Furthermore, reduced free-living ambulatory activity levels are related to poor fitness levels after stroke (LOE: 4).[96] To prevent the multiple problems associated with the deconditioned state, early intervention is recommended. Few adverse events have been reported in numerous exercise training studies of people during the early subacute,[33,97,98,99] subacute,[19,22,23,25,27,100,101,102] and chronic[18,20,21,24,26,28,29,57,65,103,104] post-stroke stages. However, at this point, evidence is lacking about the safety and effects of aerobic exercise in the acute stage.

Best Practice Recommendation 1.3

Who should determine if an individual post-stroke or TIA is ready to begin aerobic training?

Pre-participation evaluation for aerobic training after stroke or TIA should be provided by appropriately qualified health care professionals, consistent with their scope of practice and practice setting.

Level of evidence: C (Expert opinion based on standard practice)

Rationale

Stroke survivors present with a diversity of sensory-motor impairments, neuro-cognitive deficits, and co-morbidities that need to be considered in selecting evaluation strategies to determine safety and suitability for exercise stress testing and aerobic training. Therefore, health care professionals with the academic training, clinical knowledge, and skills to make sound clinical judgments should determine readiness of people post-stroke to engage in aerobic training.

System Implications

- Development and delivery of an educational program to train appropriate health care providers to perform exercise screening tests for aerobic exercise interventions
- Access to appropriately trained health care providers (e.g., neurologists, cardiologists, physical therapists, physiatrists, kinesiologists, exercise physiologists)

Performance Measures

- Availability of appropriately trained health care providers to conduct appropriate screening for aerobic exercise interventions for people after stroke or TIA.

Measurement Notes

Data gathering with regard to personnel qualifications requires an operations/administration audit.

Summary of the Evidence

The personnel qualifications to determine the readiness of a patient post-stroke to participate safely in aerobic exercise interventions have not been systematically studied.

Best Practice Recommendation 1.4

What information is needed to determine if an individual post-stroke or TIA is ready to begin aerobic training?

Before engaging in aerobic training, all individuals post-stroke or TIA must undergo a screening assessment to identify medical conditions that require special consideration or constitute a contraindication to exercise. Information to support screening should include:

- **i. General information: demographics, medical history, medications, cardiac history, seizure history, diabetes control, lifestyle habits,**
- **ii. Assessment of contraindications to exercise testing and training,**
- **iii. Evaluation of motor function, mobility, balance, swallowing, cognition (ability to follow simple instructions), and communication (verbal and non-verbal comprehension, ability to express pain or distress).**

Level of evidence: A (The majority of RCTs on aerobic exercise post-stroke have involved comprehensive screening protocols to ensure safety of participants.)

Rationale

Pre-participation screening for aerobic training post-stroke warrants careful attention because of the high prevalence of associated heath conditions, cardiovascular co-morbidities, and stroke-related functional impairments. Prescription of an effective and individualized exercise program should only be done after careful clinical evaluation, including risk stratification. The principal purpose of screening is to determine whether aerobic training is indicated and safe for a particular individual. Given that most patients post-stroke are deconditioned, it is reasonable to assume that most would benefit from enhanced physical activity. However, proper screening facilitates assessment of whether potential participants are free of health/medical conditions that could be adversely affected by aerobic exercise and guides clinical decision-making about goal setting, exercise prescription, and the level of supervision required. It is important to note that the potential benefits of aerobic exercise most often exceed the potential risks.

Screening protocols must include information to ensure sound decision-making about safe participation in and prescription of aerobic training after stroke or TIA. Because of the systemic nature of impairments typically associated with stroke, multiple factors must be considered. At the same time, the screening process should not be so onerous as to be a significant barrier to participation. Assessment of baseline status should include the information noted above. Box 1.4 outlines contraindications to aerobic exercise testing and training adapted from ACSM.[17] Details of medications (i.e., indications, response, and side effects) that can influence the test protocol and response to aerobic exercise are important to note. The electronic Physical Activity Readiness Medical Examination (ePARmed-X)[105] (Appendix A) is a useful tool to support screening of people post-stroke living in the community. In addition, laboratory tests, including echocardiograms, pulmonary function tests, investigations of peripheral vascular function, blood chemistry tests, bone density measures, radiographs, scans, thyroid function tests, and glucose tolerance tests, are useful but may not be routinely available.

System Implications

- Access to the assessment procedures and medical records is needed for pre-participation screening.
- Providing aphasia-friendly materials and augmentative/alternative communication devices ensure that individuals with non-verbal communication but sufficient comprehension are not excluded during screening.

Performance Measures

- Extent of missing data on the pre-participation screening form.

Measurement Notes

Missing data may be due to insufficient information in the health care record or certain diagnostic tests not indicated or performed during hospital stay.

Summary of the Evidence

Below is an overview of considerations referred to in the literature regarding pre-participation screening for aerobic training after stroke or TIA. It is important to note that, in order to control for confounding influences, eligibility criteria used in exercise trials are often stricter than what would be necessary in clinical practice.

Blood pressure

For cardiac populations, either resting SBP >200 mmHg or resting DBP of >110 mmHg has been deemed a contraindication for exercise or physical activity.[17] Katz-Leurer and colleagues[27] (LOE: 2) used the ACSM criteria[17] in screening individuals for participation in an early post-stroke training study, as did Tanne et al.[23] (LOE: 2) in an exercise trial involving people who sustained a minor ischemic stroke and Nadeau et al.[106] (LOE:1) before enrolling people 2 months post-stroke in a vigorous exercise trial. In contrast, in a community-based trial, Stuart and colleagues[20] (LOE: 3) chose more conservative exclusion criteria: resting SBP >160 or resting DBP >95 mmHg. Other investigators indicated that "uncontrolled hypertension" was an exclusion criterion.[19,23,26-29,33,34,57,65,107] For individuals on vasodilators, calcium channel blockers, angiotension-converting enzyme inhibitors, and α- and β-adrenergic blockers, the blood pressure response may be attenuated and, consequently, cannot be accurately predicted.[17]

Body weight

Physical activity has been recommended as a component of post-stroke weight management and obesity prevention.[108,109] Only one post-stroke study was cited in which individuals were excluded based on excessive body weight (defined as >110 kg).[37] Among the post-stroke training studies reviewed, the highest mean body mass index reported was 32.8m^2/kg.[58] Availability of personnel and equipment to accommodate bariatric individuals is an important management consideration.

Glucose tolerance/DM

The ACSM[17] recommends conducting a thorough medical evaluation on individuals with DM before they engage in vigorous exercise. Because hypoglycemia is a common problem for people with DM, rapid decreases in blood glucose may occur during exercise, causing shakiness, weakness, and abnormal sweating as well as neuroglycopenic symptoms (e.g., confusion, disorientation). Consequently, blood glucose should be monitored before and following exercise testing and training, especially in the early stages.[17] One training study[34] (LOE: 2) used an exclusion criterion with respect to diabetes control, excluding individuals early post-stroke with blood sugar levels consistently higher than 13.9 mmol/L (250 mg/dl). In a 2014 trial, people with uncontrolled diabetes unresponsive to medication and diet were also excluded.[106]

Cardiac disease

A number of the post-stroke training studies excluded people with serious associated heart disease.[19,23,26-29,33,34,57,65,107] In their trial of people within one month of stroke, Duncan and colleagues[19] (LOE: 2) defined "serious cardiac conditions" as: (i) conditions requiring hospitalization for heart disease within 3 months, (ii) active angina, (iii) serious cardiac arrhythmias, (iv) hypertrophic cardiomyopathy, (v) severe aortic stenosis, (vi) pulmonary embolus, or (vii) infarction. Nadeau et al.[106] also excluded people who met the New York Heart Association criteria for Class 3 or Class 4 heart failure - people with history of serious chronic obstructive pulmonary disease or use of supplemental oxygen and those with angina or dyspnea during rest or activities of daily living. Ramas and colleagues[110] also found that people post-stroke with cardiovascular co-morbidities were often excluded in studies involving gait training. Likewise, the review by Pang and colleagues[30] found that most studies involved people post-stroke who did not have unstable or serious cardiovascular conditions.

Carotid stenosis

Carotid stenosis is frequently seen in people with coronary artery disease[111] and is a strong independent predictor of recurrent stroke or TIA.[112] It is not listed by the ACSM as a contraindication;[17] however, Ivey and colleagues[113] stated that hemodynamically significant carotid stenosis should be regarded as a relative contraindication to maximal exercise testing. In one of their studies, two of a total of 111 individuals in the chronic post-stroke period (<2%) were excluded from participation in an aerobic training study due to carotid stenosis.[114] The rationale for exclusion was that exercise-induced dysrhythmias or other abnormal cardiac responses to exertion can produce rapid reductions in blood pressure that could potentially decrease cerebral blood flow across a fixed stenosis. For individuals with carotid stenosis who are not operative candidates, best clinical judgment of the risk-benefit ratio should be made on an individual basis with appropriate medical consultation. Careful cardiopulmonary monitoring is recommended to assure hemodynamic tolerance to the prescribed exercise intensity.

Atrial fibrillation (AF)

Both persistent and paroxysmal AF are strong predictors of recurrent stroke, particularly in older adults,[115] and sometimes coexist with carotid stenosis.[116] Exercise training in individuals with AF has received little attention in the literature. Only a few post-stroke training studies excluded people who presented with AF or other arrhythmias.[19,26-28,33,34] Vanhees et al.[117] reported that, although AF adversely affects exercise performance, it does not preclude the beneficial effects of CV training and, as a result, should not be a contraindication to exercise.

Seizure activity

During the acute phase of ischemic stroke, partial or secondary generalized seizures may occur.[118] Rimmer and colleagues[58] reported that one participant out of a group of 35 experienced a mild seizure during a 12-week training program. While the relationship between epilepsy and exercise remains a subject of controversy, reduced incidence of seizures while exercising has been well documented.[119,120] Protective strategies (e.g., wearing hip protectors, exercise in a supported position) should be used during aerobic training if seizure activity is a possibility.

Arthritis

The ACSM[17] recommended reviewing orthopedic problems such as arthritis, joint swelling, and other conditions that may limit ambulation or present challenges during exercise testing. Investigators running post-stroke training studies have used the following as exclusion criteria: inflammatory or degenerative joint diseases,[27] limiting arthritis,[65] significant musculoskeletal problems from conditions other than stroke,[28] musculoskeletal impairments or pain that would limit pedaling ability,[22] and severe pain on weight bearing.[19] Although presence of severe arthritic conditions involving the lower extremity joints can limit participation in aerobic training after stroke, availability of water-based exercise reduces that limitation.

Baseline exercise capacity/activity tolerance

Only one post-stroke training study specified a minimum activity tolerance level as an inclusion criterion: specifically, an activity tolerance of 60 minutes with rest intervals (LOE: 4).[26] Nonetheless, the extent of impairment in baseline activity tolerance may impact aerobic exercise outcomes. In a study involving sedentary and moderately obese females, participants who had lower aerobic capacity at baseline demonstrated the greatest improvements of aerobic capacity at the end of the study. Consistent with this finding, Pang and colleagues[30] (LOE: 1) noted in their meta-analysis that acute stroke survivors had greater improvements in peak oxygen consumption ($VO2_{peak}$) compared to subacute and chronic stroke survivors. The authors suggested that this outcome may have been due to the lower baseline aerobic capacity of the individuals early post-stroke as well as superimposed natural stroke recovery.[30] In a study by Tang et al.,[121] arterial stiffness of ambulatory, community-dwelling individuals post stroke was greater than that of non-disabled controls and was correlated with $VO2_{peak}$. These findings are clinically relevant because arterial stiffness is associated with increased myocardial demand and reduced coronary perfusion and, hence, is a risk factor for stroke and other adverse cardiac outcomes.[122]

Motor control of hemiparetic extremities

Impaired neuromotor control is one of the contributing factors to functional limitations in stroke survivors because these impairments may limit or restrict movements required to attain cardiorespiratory improvements.[18-28,123] Chen et al.[124] reported that $VO2_{peak}$ is dependent on the severity of lower extremity hemiparesis regardless of the types and locations of stroke. In their training study involving individuals early after stroke, Tang and colleagues[22] (LOE: 3) used a Chedoke-McMaster Stroke Assessment leg impairment score of at least 3 (marked spasticity and weakness) but less than 7 (normal limb movement) as an inclusion criterion. However, in clinical settings with access to exercise training modalities that accommodate both ambulatory and nonambulatory patients, the level of baseline motor control should not restrict participation in aerobic exercise.

Cognitive and communication status

More than 60% of stroke survivors have cognitive disabilities that may decrease the likelihood of successful rehabilitation outcomes.[125,126] Several training studies used exclusion criteria related to cognitive and language impairments because these deficits could potentially compromise ability to provide informed consent and to report adverse exercise-induced symptoms. Most used minimum scores on the Folstein Mini-Mental State Examination – <16,[19] <21,[23,34] and <24[26] (out of 24) – sometimes with adjustments for lack of formal education. Eng et al.[127] suggested that individuals with receptive or expressive aphasia be evaluated on an individual basis to determine their ability to follow instructions. Many studies operationally defined the ability to safely participate in exercise from a cognitive perspective as the ability to follow three-step commands and to interact with the exercise tester, trainer, or instructor to indicate discomfort or distress.[46,106] Clinically, to ensure safe participation in exercise testing and aerobic exercise, the participant should be able to express pain or distress and follow simple instructions.

Emotional well-being

Depression is common post-stroke and can be a substantial barrier to long-term engagement in physical activity. Although assessment of post-stroke depression by a trained professional is recommended[128] there is no consensus on the most appropriate screening tool for this purpose.[118,129] Some of the training studies reviewed excluded individuals with untreated major depression.[23,29,57,113] However, there is growing evidence that exercise can reduce depressive symptoms in people post-stroke who do not have major depression.[20,69]

Balance

Balance impairments post-stroke may result in difficulties in performing functional tasks (e.g. sitting, standing, and walking) due to the lack of postural stability.[67] Although balance deficits may represent barriers to safe participation in exercise testing and training,[17] the use of safety harnesses and supported exercise modes reduce safety concerns. Nevertheless, caution is needed regarding locomotor task practice in the free-living environment, where increased falls have been reported among more severely gait-impaired participants post-stroke.[130]

Mobility

Several investigators have used, as an eligibility criterion, the ability to walk a minimal distance with or without an assistive device: at least one step with or without assistance,[34] 3 metres (10 feet) with no more than one-person assistance;[106] 5 metres (16.4 feet),[22] 7.6 metres (25 feet),[19] or 15.2 metres (50 feet),[58] Stuart[20] used gait speed as a inclusion criterion: ability to walk independently at a speed of 30-90 cm/sec for 6 minutes, with or without an assistive device. In the LEAPs protocol, those unable to ambulate at least 46 metres (150 feet) prior to stroke, or experienced intermittent claudication while walking less than 200 metres (656 feet) were excluded.[106] Eng et al.[127] suggested participants should be able to safely and independently rise from a chair, stand, and walk 3 metres (10 feet). In the clinical setting, however, a range of exercise training modes are available to accommodate individuals with various types of mobility restrictions.

Other neurologic conditions

Special considerations should be made for other neurologic conditions superimposed on stroke deficits. For example, Parkinson Disease may introduce additional concerns for testing and training due to abnormalities of gait and autonomic dysfunction.[131]

Box 1.4 Contraindications to aerobic exercise testing and training (Adapted[17])

Signs and symptoms	***Contraindications***
Myocardial infarction	Acute myocardial infarction
Angina	Unstable angina (not controlled with medication/intervention)
Cardiac arrhythmias	Uncontrolled cardiac arrhythmias causing symptoms or hemodynamic compromise
Resting ST segment displacement	>1mm displacement in more than one lead
Heart failure	Uncontrolled symptomatic heart failure
Aortic stenosis	Symptomatic severe aortic stenosis
Large vessel intracranial stenosis	Severe stenosis
Aortic dissection	Acute aortic dissection
Endocarditis	Active endocarditis
Myocarditis/pericarditis	Suspected or known acute myocarditis or pericarditis
Hypertension	Resting SBP >200 mmHg or resting DBP >110 mmHg
Pulmonary embolus or infarction	Acute pulmonary embolus or pulmonary infarction
Metabolic diseases	Uncontrolled diabetes, thyrotoxicosis, or myxedema
Acute systemic infection	Accompanied by fever, body aches, or swollen lymph glands
Impaired cognitive function	Only if inability to understand risks associated with exercise and/or to express pain or distress presents a safety concern
Dysphasia	Inability to understand risks associated with exercise and/or to express pain or distress
Emotional distress/psychosis	Significant emotional distress
Dizziness	Severe motion-induced dizziness/vertigo
Arthritis	Severe pain on weight bearing or exercise
Seizures	Uncontrolled seizure disorder

Best Practice Recommendation 1.5

When is an exercise stress test indicated in pre-participation screening for aerobic training after stroke or TIA?

Whenever feasible, a symptom-limited or submaximal exercise stress test should be a component of pre-participation screening for aerobic training after stroke or TIA. However, if the planned aerobic intervention is to be conducted at the lower end of exercise intensities (for example, <50% of predicted heart rate reserve), a submaximal exercise test may be an option.

Level of evidence: C (Expert opinion - use of a planned exercise intensity of 50% of predicted heart rate reserve as the threshold for requiring an exercise stress test has not been systematically validated in people after stroke or TIA.)

Rationale

Exercise testing assists in assessing the safety of physical exertion, evaluating cardiorespiratory fitness, and diagnosing asymptomatic and symptomatic coronary artery disease. The test results can also provide objective data for interpretation of cardiopulmonary and hemodynamic responses to exercise and prescription of a safe, effective, and individualized aerobic exercise program. As such, a stress test can yield useful information for any person after stroke or TIA, regardless of the planned intensity of the exercise program since abnormal cardiovascular responses may occur even at low exercise intensities.

The above recommendation of using the planned training intensity to determine the need for stress testing is based on the relationship between exercise intensity and risk of cardiovascular events: low intensity exercise has the lowest risk and high intensity exercise has the highest risk.[17]

Mandating that a pre-participation stress test must be done in all cases may impose a significant clinical barrier to implementation of aerobic training programs that would be counterproductive to the goal of optimizing physical activity after stroke. An existing guideline states, "*From a practical standpoint, it may not be possible, for a variety of reasons, for many stroke patients to perform an exercise test before they begin an exercise program. For patients for whom an exercise ECG is recommended but not performed, lighter-intensity exercise should be prescribed. The reduced exercise intensity may be compensated for by increasing the training frequency, duration, or both.*"[132 pg. 2035] However, care must be taken to ensure that low-intensity exercise is not prescribed simply to circumvent the need for an exercise stress test.

System Implications

- Timely access to exercise testing, when indicated.

Performance Measures

- Percentage of individuals who have been appropriately tested according to relevant clinical criteria
- Time between exercise test requisition and actual scheduling of exercise test

Summary of the Evidence

There is evidence of increased mortality and cardiovascular event risk during symptom-limited stress testing in older individuals and individuals with mobility limitations or with chronic medical conditions.[17] However, in a 2015 review of 112 exercise trials involving over 5000 people post-stroke or TIA investigators reported no serious adverse events (i.e., death, myocardial infarct, stroke) during or following stress testing.[133] Importantly, the prevalence of electrocardiogram (ECG) abnormalities (e.g., ST-segment depression, ventricular tachycardia, ventricular arrhythmias) was highest (about 8%) of people with moderate or severe stroke involved in the studies using a symptom-limited testing protocol and lowest during submaximal tests (2%).[133] The higher prevalence rates with symptom-limited tests, reflects the direct relationship between stress imposed and probability of eliciting and detecting abnormal physiological responses, supporting the use of planned exercise intensity to determine the threshold for stress testing for individuals after stroke or TIA. If higher intensity is anticipated during aerobic training, a negative symptom-limited test provides greater assurance of a safe response to the metabolic stress to be imposed during training.

HRR (Box 1.5) is a valid indicator of exercise intensity because a certain percentage of HRR is the equivalent of the same percentage of the oxygen consumption reserve (the difference between maximum oxygen consumption [VO_{2max}] and resting oxygen consumption).[134] The most commonly used classification of aerobic exercise intensity is: *light* (<40% HRR), *moderate* (40-59% HRR) and *vigorous* (≥60% HRR).[135] The minimum effective training intensity for very unfit individuals has been reported to be 30% of resting oxygen consumption (VO_2), which approximates 30% HRR.[136]

Currently, substantial disparity exists between research protocols and clinical practice regarding use of stress tests for screening people post-stroke for aerobic exercise. Two recent reviews reported that stress tests with an ECG were routinely conducted for screening in the majority of exercise trials reviewed.[54,133] In contrast, a 2017 survey of 568 licensed American physical therapists revealed that less than 2% of respondents used stress test results for aerobic exercise screening of individuals post-stroke although 25% believed that an exercise stress test was necessary.[137] Similarly, in a survey of 155 Canadian physical therapists, stress test results were used by 2% of respondents for screening neurological patients whereas heart rate response to low intensity exercise was used by 66%.[138]

The usefulness of exercise stress testing as a pre-participation screen has been well documented in the literature related to cardiac rehabilitation but not stroke. An exercise trial by Prior and colleagues[14] (LOE: 4) involving 94 people early after mild stroke or TIA used data from the baseline treadmill test to calculate the Duke Treadmill Score (a measure of mortality based on total exercise capacity, ST shift, and the presence of non-limiting or limiting angina[139]) and found that participants were almost evenly divided between moderate and low risk for a fatal cardiovascular event over the next year.[14] In their "Call for action" paper, Piepoli and colleagues[140] (LOE: 5) recommended that, prior to beginning physical activity, symptom-limited maximal exercise testing should be mandatory to assess exercise capacity and exercise-induced ischemia in patients with DM. However, given the high prevalence of DM in the stroke population (in the order of 25%[141]) and the often limited availability of exercise testing, this recommendation may not be feasible in some clinical settings.

In a multi-centered exercise RCT of people post-stroke, a cardiovascular screening inventory was administered prior to a stress test to assess cardiac medical history, cardiac disease risk factors, family cardiac history, and current medications.[106] Participants for whom exercise testing was contraindicated were referred to their primary care physician for appropriate follow-up.[106]

Box 1.5 Calculation of heart rate reserve (HRR

Heart rate reserve is maximum heart rate (HR_{max}) minus resting heart rate (HR_{rest}):

$HRR = HR_{max} - HR_{rest}$

HR_{rest} is measured following a minimum of 5 minutes of quiet sitting (i.e., no movement or talking), either manually for 60 seconds or using a heart rate monitor.

HR_{max} is best obtained directly from a maximal exercise test. Alternatively, HR_{max} can be predicted using a formula:

Predicted $HR_{max} = 220 - age$ can be used but for a more accurate estimation use the formula:

Predicted $HR_{max} = 206.9 - (0.67 \times age)$[142]

If the patient is on a beta-blocker, estimation of HRmax is adjusted with the formula:

Predicted $HR_{max} = 164 - 0.7 \times age$[142]

Target heart rate for aerobic training prescription is calculated using the Karvonen formula:[143]

$HR = HR_{rest} + (X\% \text{ of } HRR)$

X% of HRR is selected based on the planned exercise intensity:[135]

- Low intensity = <40% of HRR
- Moderate intensity = 40% - 60% of HRR
- High intensity = >60% of HRR

Best Practice Recommendation 1.6

How should exercise testing, as a component of the pre-participation screen for aerobic training after stroke or TIA, be conducted?

Symptom-limited or submaximal stress tests with ECG monitoring involve an adequate warm-up and cool-down and are administered by appropriately trained and experienced health care professionals with direct access to physician support and an external defibrillator. The participant should be on usual medications, avoid any strenuous activity for 24 hours prior to testing, and avoid a heavy meal, caffeine, or nicotine within 2 to 3 hours of testing.

Submaximal exercise tests involve walking, stepping, or cycling at a workload consistent with the planned intensity of the training program. Alternatively, submaximal field tests (e.g., Six-Minute Walk Test or Shuttle Walk Test) can be used, which usually entail walking a predefined time or distance.

Level of evidence: C (Expert opinion)

Rationale

The type of exercise test used depends on several factors, including the targeted exercise intensity of aerobic training, availability of appropriate equipment and personnel, and the population to be tested. Regardless of the test used, the patient should become familiar with the equipment and testing protocol prior to performing the actual test.

System Implications

- Availability of equipment and trained personnel for exercise testing.
- Availability of emergency equipment (e.g., paging system, emergency medical cart, sugar source for individuals with DM) to ensure prompt medical response to adverse events during testing.
- Scheduling of safety and calibration check of equipment.

Performance Measures

- Percentage of people post-stroke who received a peak effort or submaximal exercise stress test prior to participation in aerobic training programs involving intensities >50% HRR
- Percentage of people post-stroke who received a submaximal field test prior to participation in aerobic training programs involving intensities <50% HRR

Measurement Notes

- Data from maximal exercise tests include peak heart rate, % predicted HRmax, peak blood pressure, peak rating of perceived exertion, exercise time, presence and type of ECG abnormalities.
- Data from submaximal exercise tests include heart rate, blood pressure, rating of perceived exertion at a fixed workload, presence and type of ECG abnormalities.

Summary of the Evidence

In a 2015 review of 112 exercise trials involving people post-stroke or TIA symptom-limited stress tests were used in 87% of the studies, submaximal tests in 8%, field tests in 5% and pharmacological tests in 0%.[133]

Symptom-limited exercise tests (Box 1.6a) VO_{2max} (or VO_{2peak} in the case of people who cannot meet the criteria for a maximal test, such as individuals who are elderly, deconditioned or have cardiovascular disease[144]) can be measured during a symptom-limited exercise test, but more often in research settings than in clinical practice. VO_{2max} or VO_{2peak} is commonly referred to as the definitive index of cardiovascular fitness.[145] (It has been postulated that ventilatory threshold may a better predictor of aerobic capacity because VO_{2peak} is affected more by motor dysfunction.[146]) Peak heart rate achieved during a maximal exercise test can be used to estimate VO_{2max}, because of the linear relationship between VO_2 and heart rate. However, while VO_2 is relatively impervious to testing conditions, heart rate is markedly affected by various factors (e.g., anxiety, dehydration, changes in body temperature, exercise mode), thus limiting the accuracy of the estimation.[147] In fact, discrepancies between VO_{2max}

estimated using heart rate data and measured VO_{2max} in individuals with low exercise capacity can be as high as 25%.[148] It is also worthy of note that peak workload and total exercise time are not reliable indicators of maximal effort because they are dependent on the test protocol.[149]

Because symptom-limited testing requires patients to exercise until volitional fatigue, medical supervision is advised, particularly for high-risk individuals with symptomatic, or known cardiac, pulmonary, or metabolic disease.[17] The optimal duration of a symptom-limited test is 8-12 minutes. The test should begin at low workloads, using small workload increments between progressive stages of the test (i.e., ramp or step protocol);[150] alternatively, a discontinuous, progressive protocol (i.e., with rests between stages) can be used but is less common.

Submaximal exercise tests (Box 1.6b) The ACSM[17] cautions that older individuals and individuals with mobility limitations or with chronic medical conditions may not be able to perform the vigorous-intensity exercise required for standard maximal exercise testing protocols. Submaximal exercise tests can be used for screening, particularly if low-intensity training is planned.[17] The main goal of either single or multi-stage submaximal exercise tests is to determine the heart rate response to submaximal work rates and estimate VO_{2max} by extrapolating the relationship between heart rate and VO_2 to the age-predicted HR_{max}.[17]

According to the ACSM,[17] maximal treadmill testing protocols can be applied to submaximal exercise testing, with termination of the test when the target percentage of predicted HR_{max} has been attained. The ACSM[17] advises that the stages of the test should be at least three minutes to ensure that the patient achieves a steady-state heart rate at each stage. Submaximal testing protocols, such as the Åstrand-Ryming Nomogram,[151] estimate VO_{2max} from heart rate measurements taken at a fixed work rate or test duration at a given power output on a cycle ergometer or at a given grade and speed on a treadmill. However, these protocols have not been validated in the stroke population, and the accuracy of using heart rate to determine VO_{2max} is limited.[148] An alternative test for patients post-stroke on beta blocking agents or with atrial fibrillation is the Graded Cycling with Talk Test.[152]

Submaximal field tests consist of stepping or walking a predefined time (e.g., 6MWT) or distance.[17] Limitations of such tests include the influence of motivation and functional ability on accuracy of the results and infrequent monitoring of heart rate and blood pressure.[17] One advantage of the 6MWT is that the participant tends to walk at a constant pace near their critical power; thus VO_2 is in a steady-state condition for most of the test. Further, predictive equations permit assessment of the distance covered relative to normative values.[153] However, within the stroke population, Eng and colleagues[154] found weak correlations between distance walked and VO_{2peak}, as well as between heart rate at the end of the 6MWT and VO_{2peak}. Tang et al.[155] reported similar results, leading them to conclude that, because the distance walked depends greatly on the ambulation status of the patient post-stroke, the 6MWT alone is not an adequate measure of aerobic fitness.

Pharmacological stress tests are reliable for detecting coronary artery disease in patients post-stroke, but they are expensive to conduct as initial screens for exercise training and may be inadequate to define the cardiovascular response to physical exertion.[156,157] Dobutamine stress echocardiography, a non-exercise-dependent stress modality, has been used to screen patients post-stroke for cardiac risks prior to participation in strengthening and physical conditioning.[18] Rokey and colleagues[158] reported that treadmill testing with Thallium-201 scintigraphy and exercise radionuclide ventriculography revealed significant coronary artery disease in 58% of 50 patients after TIA or mild stroke, half of whom were without prior known history of cardiac disease. Using bicycle exercise Thallium-201 myocardial scintigraphy, Di Pasquale[159] found asymptomatic coronary artery disease in 6% in control subjects and 28% of 83 patients post TIA or mild stroke who lacked symptoms or ECG signs of coronary artery disease.

Mode of exercise tests is particular importance because a valid indication of exercise capacity requires activation of at least 50% of the body's total muscle mass.[147] Treadmills and cycle ergometers are the most commonly used modes of maximal exercise testing.[17] Treadmill testing tends to elicit the greatest metabolic response, although Modai et al contended that stair climbing tests are more metabolically demanding than treadmill testing.[160] The treadmill is a testing mode familiar to most individuals because the muscle activation closely resembles the mobility patterns utilized in everyday living.[132] Also, termination of treadmill exercise tests is less likely than cycle ergometer tests to be due to leg muscle fatigue.[161] Use of an ankle foot orthosis during low-velocity graded treadmill testing resulted in increased values of VO_{2peak}.[162] Compared to land treadmill tests, aquatic treadmill tests achieve significantly higher VO_{2peak} and peak rating of perceived exertion (RPE), decrease the risk of injury by reducing the musculoskeletal load, and enhance self-efficacy of individuals concerned about fall risk.[163]

Cycle ergometer tests may be more suitable than treadmill tests for individuals post-stroke with moderately severe balance or motor impairments.[161,164] Cycle ergometer tests yield 90-95% of VO_{2peak} achieved using a treadmill test.[161] However, cycle ergometry may provide more reliable blood pressure measurements and ECG recording because it involves less arm and torso movement.[161,164] The ACSM[17] advises against use of electronically braked cycle ergometers because they cannot be calibrated.

Arm crank tests yield ~70% of VO_{2peak} achieved using a treadmill test[147] because arm cranking activates a smaller muscle mass than treadmill or cycle ergometry testing, thereby limiting the reduction in total peripheral resistance and potentially increasing the blood pressure response. Upright, semi-recumbent or recumbent bikes, which have the potential to activate a large muscle mass by involving all four extremities, are often the mode of choice for severe disability.[133]

Warm-up and cool-down Regardless of the exercise testing protocol employed, a warm-up 3-5 minutes in duration at a metabolic rate about twice resting level (i.e., 2 metabolic equivalents [METs]) is recommended to prevent premature and excessive local muscle fatigue.[17] Similarly, testing should be followed with a 3-5 minute cool-down to support venous return to prevent pooling of blood in the peripheral vasculature and a subsequent drop in DBP.

Box 1.6a Symptom-limited exercise test protocols specifically adapted for people post-stroke	
Test	***Description***
Semi-recumbent cycle ergometry	*General description:* Symptom-limited semi-recumbent cycle ergometry exercise test[155] *Stroke population studied:* Mean of 17.6 days post-stroke[155] Protocol: Ramp protocol beginning a 2-minute warm up at 10 watts at a target cadence of 50 revolutions/min, followed by progressive 5-watt increases in work rate every minute[165] *Test-retest reliability*: ICC = 0.50 for VO_{2peak}, 0.74 for peak heart rate[155] *Validity:* 9% of participants reached a peak heart rate within 10 beats/minute of age-predicted HR_{max}[155]
Modified total-body recumbent stepper exercise test	*General description*: Symptom-limited total-body recumbent stepper test (mTBRS-XT)[166] *Stroke population studied:* Mean of 40 months post-stroke[166] *Protocol*: 2-minute stages at a stepping cadence of 80 steps/minute with an initial resistance of 25 watts, which is increased at each stage. Test is terminated when one of the following conditions has been reached: (i) volitional fatigue, (ii) VO_2 plateau (iii) inability to maintain cadence; or (iv) adverse cardiovascular event.[166] *Test-retest reliability*: $ICC_{3,1}$ = 0.94 for VO_{2peak}, 0.93 for peak heart rate[166] *Validity*: Correlations between mTBRS-XT and cycle ergometry - VO_{2peak}, r = 0.91, peak heart rate, r = 0.89[166]
Combined upper and lower limb ergometer	*General description:* Symptom-limited test using combined upper-lower limb ergometer[167] *Stroke population studied:* Mean of 7.3 weeks post-stroke[167] *Protocol:* 3-minute stages at a cycling cadence of 30-40 rpm with resistance increased at each stage until test termination (resistance applied was not reported)[167] *Test-retest reliability:* Not reported Validity: 75%$\pm$11% of age-predicted HR_{max} achieved using this protocol[167]
Treadmill test	*General description:* Symptom-limited treadmill test[168] *Stroke population studied:* Mean of 2 years post-stroke[168] *Protocol:* Test initiated at 70% of 10-metre walk speed and 0% treadmill grade. Test terminated upon reaching 100-120% of 10-metre walk speed and 5% treadmill grade.[168] *Test-retest reliability:* Not reported Validity: VO_{2peak} achieved was, on average, 9% higher than reference test (p=0.04)[168]
Body-weight supported treadmill test	*General description:* Symptom-limited treadmill test with body weight support[94] *Stroke population studied:* Mean of 26 days post-stroke[94] *Protocol:* 15% of body weight is supported throughout test. 2-minute stages beginning with walking at self-selected speed and 0% treadmill grade for 2 minute, followed by a 2.5% increase in grade every 2 minute until an incline of 10% is reached and, thereafter, a .05m/s increase in speed every 2 minute, until test termination[94] *Test-retest reliability*: $ICC_{3,1}$ = 0.94 for VO_{2peak}, 0.93 for peak heart rate[94] *Validity:* 86.4%$\pm$11% of age-predicted HR_{max} achieved using this protocol[94]
Robotic-assisted tilt table test	*General description:* Symptom-limited treadmill test[169] *Stroke population studied:* Subacute and chronic stroke[169] *Protocol:* 3 phases – (i) 3-minute rest phase with patient secured on tilt table at 70° angle. (ii) 5-minute robotic movement of legs with measured workload adjusted to 0 watts. (iii) Ramp phase with work rate increased by active stepping to 1.25-4.5 watts/minute (individualized), with test terminated when maximal effort is reached.[169] *Test-retest reliability*: $ICC_{3,1}$ = 0.84 for VO_{2peak}, 0.90 for peak heart rate[169] *Validity:* 78%$\pm$15% of age-predicted HR_{max} achieved using this protocol[169]

ICC = intraclass correlation coefficient

Box 1.6b Submaximal exercise test protocols specifically adapted for people post-stroke	
Test	***Description***
Cycle ergometer test	*General description:* Submaximal cycle ergometer test[154] *Health condition studied:* Mean of 3.5 years post-stroke[154] *Protocol:* 1-minute stages at 50 to 70 revolutions per minute, beginning at 0W, with workload increments of 20 watts/stage. End-point is the submaximal VO_2 corresponding to the VO_2 at a heart rate of 85% of age-predicted maximum[154] *Test-retest reliability*: $ICC_{2,1}$ for VO_2 = 0.93[154] *Validity:* Correlation between VO_2 and VO_{2peak}, r = 0.80[154]
Graded Cycling with Talk Test	*General description:* Submaximal cycle ergometer test[152] *Health condition studied:* Mean of 3 days (in-patients) and 43 days (out-patients) after lacunar stroke[152] Protocol: Initial 2-minute stage at 15 watts and 50 revolutions per minute, followed by 1-minute stages with workload increments of 15 watts/minute. During the last 10 seconds of every minute, the participant recites a 30-word text passage and is asked "*Are you still able to speak comfortably?*" If the participant responds "No," the test is terminated.[152] *Test-retest reliability*: $ICC_{2,1}$ for VO_2 = 0.97[152] *Validity:* Not studied
Treadmill test	*General description:* Submaximal treadmill test[154] *Health condition studied:* Mean of 3.5 years post-stroke[154] *Protocol: a* 6-minute walk beginning at a comfortable, pre-selected speed (~60% of the self-selected over ground speed), bringing the participant to a plateau of ~85% of age-predicted heart rate maximum value of the maximal cycle ergometer test within the first 2 minutes. During the first minute, treadmill speed is increased 3 times (0.5km/hour every 20 seconds). In the second minute, speed remains constant while the ramp is elevated 3 times (2% grade every 20s). The speed and ramp are then held constant for the last 4 minutes.[154] *Test-retest reliability*: $ICC_{2,1}$ for VO_2 = 0.75[154] *Validity:* Correlation between VO_2 and VO_{2peak}, r = 0.71[154]
6-Minute Walk Test (6MWT)	*General description:* Submaximal walking test[154] *Health condition studied:* Mean of 3.5 years post-stroke[154] *Protocol:* Walking at self-selected speed for 6 minute, inclusive of rest intervals[154] *Test-retest reliability*: $ICC_{2,1}$ (for VO_2) = 0.96, $ICC_{2,1}$ (for distance covered) = 0.99;[154] distance covered with a 7-day interval varied by 20.5$\pm$27m[170] *Validity:* Correlation between 6MWT VO_2 and VO_{2peak}, R = -0.66; between 6MWT distance and VO_{2peak}, r = -0.37; between heart rate at end of 6MWT and VO_{2peak}, r = -0.18[154] *Special notes*: Wu and colleagues[171] suggested that in the rehabilitation setting a single 6MWT may be adequate, provided that modest learning effects are considered when interpreting the results.

ICC = intraclass correlation coefficient; R = correlation coefficient

Best Practice Recommendation 1.7

What should be monitored during a screening exercise test?

During screening exercise tests clinical signs and symptoms, heart rate, blood pressure, and rating of perceived exertion should be monitored before, during, and after termination of the test until baseline values have been approximated. If an exercise stress test is used, continuous monitoring of electrocardiography should also be conducted.

Level of evidence: A (The exercise stress testing protocols used in RCTs on aerobic exercise post-stroke have involved monitoring of heart rate, blood pressure and RPE, consistent with clinical guidelines.)

Rationale

Careful monitoring of the individual's response to exercise testing is essential to ensure safety of the test, determine when termination of the test is indicated, assess cardiovascular fitness, and collect reliable, valid information for intervention planning (e.g., contraindications to training, supervision requirements).

System Implications

- Access to monitoring equipment (e.g., sphygmomanometer, ECG)

Performance Measures

- Percentage of records with documentation of a plan for appropriate medical follow-up for individuals post-stroke with positive exercise tests

Measurement Notes

Documentation of exercise testing outcomes at each stage and ECG printout.

Summary of the Evidence

Monitoring of clinical signs and symptoms, blood pressure, and rating of perceived exertion are used to identify test termination endpoints, baseline cardiovascular fitness levels, and supervision requirements for, or contraindications to, exercise training.[172] Absolute and relative indications for terminating an exercise test are outlined in Box 1.7. *Heart rate monitoring* can also be used to assess the level of voluntary effort during exercise testing and to determine when to terminate the test, particularly if the testing protocol includes a targeted percentage of predicted HR_{max} (see Box 1.5).

Blood pressure monitoring helps determining test termination endpoints and serves as a safety precaution during the exercise test. A decrease in SBP or no increase in SBP during incremental exercise testing may indicate clinically significant myocardial ischemia, left ventricular dysfunction, or chronotropic insufficiency.[161] During exercise, DBP should either remain relatively constant or decrease.[17] BP should be measured in both a supine position and in an exercise posture before the exercise test, during the last 30-60 seconds of each test stage or every 2 minutes of ramp protocols, immediately after the test and then every 2 minutes until the readings approximate resting levels.[17]

RPE on the 0-10 or 6-20 scale should be used as an indication of the subjective effort expended during an exercise test.[173]

12-lead ECG monitoring during symptom-limited or submaximal stress testing is recommended because many individuals post-stroke are at risk of, or have, cardiovascular disease.[128] ACSM[17] advises that ECG recordings should be taken before the exercise test with the individual in supine as well as the exercise posture. ECG should be recorded during and immediately after the exercise test as well as during the last 15 seconds of the first minute post-exercise and then every 2 minutes thereafter until the readings approximate resting levels. ASCM[17] cautions that people with AF are often taking digoxin, beta-blockers, or other anti-arrhythmic agents and have left bundle branch block and left ventricular hypertrophy, making ST-segment changes during exercise difficult to interpret.

Box 1.7 Indications for terminating an exercise stress test[17]

Absolute Indications	*Relative Indications*
Suspicion of a myocardial infarction or acute myocardial infarction	Any chest pain that is increasing
Onset of moderate-to-severe angina	Physical or verbal manifestations of shortness of breath or severe fatigue
Drop in SBP below standing resting pressure or drop in SBP with increasing workload accompanied by signs or symptoms	Wheezing
Signs of poor perfusion, including pallor (pale appearance to the skin), cyanosis, or cold and clammy skin	Leg cramps or intermittent claudication (grade 3 on a 4-point scale)
Severe or unusual shortness of breath	Hypertensive response (SBP >260 mm Hg; DBP>115 mm Hg)
Central nervous system symptoms (e.g., ataxia, vertigo, visual or gait problems, confusion)	Pronounced ECG changes from baseline >2 mm of horizontal or down sloping ST-segment depression, or >2 mm of ST-segment elevation (except in aortic valve replacement)
Serious arrhythmias (e.g., second / third degree atrioventricular block, atrial fibrillation with fast ventricular response, increasing premature ventricular contractions, or sustained ventricular tachycardia)	Exercise-induced bundle branch block that cannot be distinguished from ventricular tachycardia
Technical inability to monitor the ECG	Less serious arrhythmias (abnormal heart rhythms) such as supraventricular tachycardia
Request by participant to stop	

SECTION 2. PRESCRIPTION OF AEROBIC EXERCISE INTERVENTIONS AFTER STROKE OR TIA

Best Practice Recommendation 2.1

How does aerobic training fit into the overall program of stroke rehabilitation?

Aerobic training should be incorporated into a comprehensive, inter-professional program of stroke rehabilitation, vascular risk reduction, and secondary stroke prevention. Aerobic training is part of an overall exercise program that may also include, but is not limited to, muscle strengthening and task-oriented training of motor control, balance, gait, and functional use of the upper extremity. Physical activity designed to maintain cardiovascular fitness is an important aspect of community reintegration after stroke.

Level of evidence: C (Expert opinion. Although there is strong evidence to support the efficacy of aerobic training to improve exercise capacity and function post-stroke, trials investigating the effectiveness of incorporating aerobic exercise into a comprehensive inter-professional framework are lacking.)

Rationale

Optimization of recovery after stroke or TIA usually requires a comprehensive plan of complex interventions involving a number of health care providers. Aerobic training should be regarded as a core component of stroke care. However, rather than perceiving aerobic exercise as an isolated intervention, it is preferable to incorporate training into an overall program of physical activity. In some cases, the metabolic demands of standard rehabilitation activities (e.g., progressive task-oriented exercises and mobility training) may be of sufficient intensity to elicit an aerobic training effect. However, most often exercise above and beyond the incidental physical activity accumulated in the course of structured formal rehabilitation or daily living is required. Thus, it is imperative that the intensity of exercise be monitored (see Recommendation 2.9) to ensure that an adequate intensity has actually been achieved.

System Implications

- Coordination of a comprehensive stroke management program that includes aerobic exercise interventions and is delivered by an inter-professional team
- Provision of adequate time, personnel, and communication strategies to ensure that all aspects of stroke management, including aerobic exercise interventions, are implemented as required
- Provision of equipment and facilities for aerobic exercise along the continuum of care (from inpatient rehabilitation to home and community)

Performance Measures

- Percentage of documented intervention plans that include aerobic exercise as a component of a comprehensive plan.
- Exercise plan should document nature of proposed exercise, duration, intensity, plan for progression, goals, outcome measures, and periodic reassessment.
- Proportion of individuals who participate in aerobic exercise interventions during the course of recovery from stroke or TIA.
- Proportion of people post-stroke who continue to engage in physical activity after completion of formal rehabilitation.

Measurement Notes

Performance measurement should include targeted data collection of performance measures through audits of rehabilitation records and community program records.

Summary of the Evidence

Evidence suggests that patients post-stroke have not been challenged enough in standard rehabilitation to induce the metabolic stress needed to enhance their cardiovascular fitness.[174-176] In a 2002 longitudinal study of stroke rehabilitation, investigators documented that the mean time per physiotherapy session spent in a given target heart rate zone was less than three minutes and per occupational therapy session was negligible,[174] findings that have been corroborated in a recent study.[172] Current barriers to exercise prescription identified in a survey of American physical therapists included participants' limited ability to exercise at target training levels, balance impairments, cognitive and perceptual impairments, short length of hospital stay, lack of time and exercise equipment and limited motivation.[137]

A few training studies involving people post-stroke studied the combination of aerobic and strengthening exercise interventions.[18-20,25,26] Strength training protocols were conducted at home[19,25] or in the community[20,26,177] using Theraband,[18,19,25] body weight,[18] free weights,[18,26] and uncoupled resistive training machines,[177] and training was conducted individually[19,25] or in groups.[20,26,178] Teixeira-Salmela and colleagues[18] reported that the combination of physical conditioning and muscle strengthening improved training outcomes for individuals in the chronic post-stroke period. A positive correlation (p=0.47) has been reported between aerobic capacity and the concentration of citrate synthase, a key mitochondrial enzyme, in hemiparetic rectus femoris muscle fibres.[179] However, Pang and Eng[30] concluded that further investigation is needed to determine whether aerobic exercise plus strengthening exercise is more beneficial than aerobic exercise alone in improving aerobic capacity after stroke.

Best Practice Recommendation 2.2

Where should aerobic exercise interventions be conducted?

Aerobic exercise programs can be administered in a variety of barrier-free and accessible settings: hospital, outpatient clinics, community, and home. Training of high-risk individuals must be done in a setting with immediate access to external defibrillation and emergency medical response. For lower-risk individuals, supervised home-based aerobic exercise programs may be a safe and effective option.

Level of evidence: C (Expert opinion - RCTs have demonstrated the efficacy of aerobic training post-stoke in a variety of settings, but the relative effectiveness of different settings has not been investigated.)

Rationale

Determining the most appropriate and effective setting for aerobic exercise interventions post-stroke depends on several factors. In a set of clinical practice guidelines, Duncan and colleagues[180] (LOE: B) recommended that the setting for overall stroke rehabilitation (i.e., not specific to aerobic training interventions) should be easily and safely accessible and based on medical status, functional status, social support, and access to care. Although the home setting may be the most accessible and convenient, it might be unsafe due to lack of availability to emergency medical equipment and trained personnel, and, for higher-functioning individuals, restrictive because of the absence of appropriate training equipment.[180] The guidelines concluded that, regardless of the setting, the participant should be managed by a coordinated, experienced, and organized rehabilitation team.[180]

System Implications

- Access to aerobic training interventions along the continuum of care (from inpatient rehabilitation to home and community) to ensure that the correct intervention is available to the appropriate people in the proper setting
- Barrier-free space for exercising with adequate temperature control and wheelchair access, if required, to facilitate access and ensure safety
- Access to drinking water, a source of glucose (e.g., juice), and first aid equipment
- Adverse event protocol for individuals at high risk of further vascular events or falls
- Availability of an automatic external defibrillator and emergency medical response for individuals at high risk of further vascular events

Performance Measures

Proportion of individuals post-stroke who have access to aerobic training interventions across the continuum of care (i.e., in-patients, outpatient rehabilitation centers, home, and community).

Summary of the Evidence

Post-stroke aerobic exercise training studies have been conducted in hospital settings;[21,27,31,34,65] rehabilitation centers,[22,23,33,56] community settings,[28,50,127,181-183] and home environments.[19,25,101,181] No adverse events attributable to the setting have been reported. Telehealth is a strategy being explored to help deliver aerobic training remotely, particularly in rural areas. In a study by Jones and colleagues, a self-management program (myMoves) provided via telephone and email was effective in increasing physical activity in individuals post-stroke.[184]

Best Practice Recommendation 2.3

Who should design and supervise the aerobic exercise intervention?

The aerobic exercise program should be designed by appropriately qualified health care professionals, such as physical therapists or cardiac rehabilitation specialists. The level of supervision is determined by the health care professional based on the individual participant's health condition. High-risk individuals require constant supervision whereas low-risk individuals with demonstrated ability to exercise safely and effectively may require only intermittent supervision. Supervision may be provided by a qualified health care professional or an exercise instructor who has been trained by the health care professional.

Level of evidence: C (Expert opinion - the recommendation is consistent with cardiac rehabilitation practices, but the relative effectiveness of involving different health care professionals in designing, monitoring, and supervising post-stroke aerobic exercise programs has not been studied.)

Rationale

According to the ACSM Guidelines for Exercise Testing and Prescription,[17] well-trained exercise/clinical professionals should supervise exercise programs for all individuals who are at high risk for cardiovascular disease or have a chronic disease or health condition. The Canadian Guidelines for Cardiac Rehabilitation and Cardiovascular Disease Prevention[185] recommended that all health professionals involved in cardiac rehabilitation (in which aerobic exercise interventions are a principal component) should have emergency response capability (i.e., Basic Cardiac Life Support or higher).

Rimmer et al.[186] expressed concern that use of untrained personnel in community-based gyms may limit rehabilitation outcomes of stroke survivors because of safety concerns and the potential for compromising the quality of the program. Similarly, community-based stroke survivors were apprehensive about a perceived lack of safety associated with their fitness instructors' low levels of knowledge about stroke and limited monitoring of participants while exercising.[103] Nevertheless, Johansson[187] underlined the importance of creating an environment that encourages stroke survivors to continue rehabilitation exercises and activities following completion of conventional rehabilitation. Exercise class instructors who were trained and supervised by health care professionals successfully conducted low-intensity exercise programs in community settings for older adults post-stroke.[20]

Patients discharged to home should continue their program of aerobic exercise established during formal rehabilitation, with a level of supervision determined by the health professional.

System Implications

- Credentialing of health care providers supervising individuals post-stroke or TIA during aerobic exercise along the continuum of care (from inpatient rehabilitation to home and community) to ensure acquisition of relevant knowledge (e.g., pathology and presenting signs and symptoms of stroke, stages/time course of stroke recovery, basic cardiovascular and exercise physiology/pathophysiology, common co-morbidities, vascular risk factor reduction) and skills (e.g., cardiovascular assessment, motivational/behavioral change techniques, exercise prescription and progression, emergency response procedures).

Performance Measures

- Proportion of personnel involved in designing and supervising aerobic exercise programs who have the appropriate training and credentials

Measurement Notes

Credential check of personnel supervising aerobic exercise programs

Summary of the Evidence

Rimmer et al.[186] noted a lack of research regarding the appropriate personnel to supervise aerobic training post-stroke. In the majority of training studies of people post-stroke, physical therapists supervised the exercise programs.[18-21,23,25-27,31,50,102] Other personnel included occupational therapists,[19] exercise physiologists,[18,21] kinesiologists,[26] nurses,[31] gym instructors,[20,103] student interns,[21] research staff,[22] "assistants."[24,50] and caregivers.[101] In the study by Stuart and colleagues,[20] the gym instructors employed to conduct the exercise classes were trained by physical therapists and were selected based on their experience and ability to motivate the participants. As a safety measure and to ensure exercise protocols were being executed correctly, the physical therapists visited the facility at random times throughout the program.[20]

A qualitative study exploring the perceptions of exercise among stroke survivors reported that most people in the focus group felt that exercise classes should been instructed by "professionals" with an understanding of the challenges and capabilities of people post-stroke in order to ensure safety and comfort, present necessary exercise information, and provide external motivation to exercise.[188] Wiles et al.[103] explored the views of physical therapists, patients, and fitness instructors on the appropriateness and acceptability of exercise programs conducted by fitness instructors in community gyms to which individuals post-stroke were referred by physical therapists. The physical therapists expressed concern about safety due to the fitness instructors' lack of knowledge and experience in working with stroke populations.[103] The authors identified a need for closer interaction with physical therapists and fitness instructors to ensure that the exercise programs are safe and meet the abilities and multi-faceted needs of stroke survivors.[103]

Best Practice Recommendation 2.4

What format (individual, group) should be used for aerobic training after stroke or TIA?

Aerobic exercise interventions can be conducted in either an individual (one-on-one) or group format, with the ratio of participant to supervising personnel determined by the severity of the participant's neurological and cardiac status as well as the planned exercise intensity and mode of training.

Level of evidence: B (Several RCTs have demonstrated effective application of aerobic exercise interventions after stroke using either an individual or group format. However, the level of evidence was downgraded due to a lack of stroke trials that directly compared individual and group formats.)

Rationale

Aerobic exercise for individuals who have had a minor stroke or TIA may be initiated using a group format. Individualized exercise programs may be indicated early in the recovery process for people with moderate to severe stroke to ensure safety and effectiveness by adapting the program according to the individual's presentation and by close monitoring of the individual's response to exercise. When the person is capable of more independent participation without the need for one-on-one monitoring, a group format (which may be more cost effective) should be considered. Engagement in exercise may be facilitated by the social support that a group format offers.[26]

System Implications

- Inpatient and outpatient rehabilitation settings adequately staffed to provide individualized aerobic exercise interventions
- Community-based settings adequately staffed to provide group aerobic exercise interventions
- Maximum number of participants in a class may be defined by building and fire code regulations

Performance Measures

- Ratio of participants to health professionals delivering the aerobic training sessions for individuals or groups of individuals with varying cardiopulmonary and neurologic deficit profiles

Measurement Notes

Data gathering related to participant-personnel ratios requires an operations/administration audit.

Summary of the Evidence

Direct comparison of the effectiveness of aerobic training with individuals or groups of individuals post-stroke has not been done. The majority of the post-stroke aerobic exercise programs reviewed were performed individually by the participants.[19,22,24,25,27,31,34,65,104] A qualitative study by Wiles[103] described an individualized exercise program designed specifically for people post-stroke exercising in a public gym setting. The researchers observed limited interaction among participants because the exercise programs were so individualized.[103]

All of the training studies that used a group format involved people in the chronic stages of post-stroke recovery.[18,26,28] Five studies specified the group size: 7,[28] less than 10,[102,176] 9-1,[20] and 12-13.[182,189]. A few studies specified the ratio of instructors to participants for aerobic training: 1:10 in a gym-based program,[103] 1:2, 1:5 in adapted cardiac rehabilitation programs,[85,190] and, in an 8-week water-based trial, 3:7 for the first week and 1:7 for the remaining 7 weeks.[28]

Best Practice Recommendation 2.5

What mode of exercise should be used for aerobic training after stroke or TIA?

Any mode of exercise that activates a large muscle mass for a prolonged period can be used to induce an aerobic training effect.

Level of evidence: B (Several RCTs have demonstrated effective application of various modes of aerobic exercise interventions after stroke. However, the level of evidence was downgraded due to paucity of stroke trials that directly compared different modes.)

Rationale

Because of the variability in stroke severity, selecting an appropriate training modality can be challenging. Ivey and colleagues[191] suggested that the mode of training be based on post-stroke impairments, fitness levels, stroke severity, time since stroke, and exercise prescription protocols. Selection of exercise mode is also influenced by the presence of arthritis, obesity, seizure history, or dementia. The ACSM[128] suggests the use of upper- and lower-body ergometers, cycle ergometers, treadmills, arm ergometers, and seated steppers as training modalities for aerobic conditioning post-stroke. Water-based training may be indicated for people post-stroke who are morbidly obese or have severe arthritic conditions. Given the task specificity of motor learning and motor skill reacquisition, the exercise modality should be aligned with the participant's functional goals, if feasible (e.g., treadmill training, with or without body-weight support, would be an appropriate modality if improved ambulatory status was a principal goal).

System Implications

Access along the continuum of care to exercise equipment, certified for patient use, for the safe and effective delivery of aerobic exercise interventions for individuals at various levels of functional mobility and motor control

Performance Measures

- Adequate supply of certified aerobic exercise equipment
- Percentage of participants who receive appropriate exercise modalities
- Equipment maintenance schedules with checklists and documentation of calibration and repairs

Measurement Notes

Equipment inventory should be part of the audit process.

Summary of the Evidence

Although the relative effectiveness of aerobic exercise modalities has not been directly investigated in the stroke population,[186] modes commonly used with non-disabled people have been proven to be capable of eliciting a 10-15% increase in cardiorespiratory fitness in people post-stroke.[54] The majority of exercise studies reviewed used either treadmill training[23,24,29,33,34,46,56,57,59,86,192] or cycle ergometry.[18,19,21-23,25,27,41,58,65,104] Other studies employed stair machines,[23] steppers,[18,21,26] walking circuits,[20,26,53] stepping,[193] adapted cardiac rehabilitation,[194,195] circuit training,[50,171] aquatic exercises,[28] and underwater treadmill training.[196,197,196]

Treadmill training Gordon and colleagues[132] noted three advantages of treadmill training for stroke survivors: (i) locomotor training that can be applied to daily tasks such as walking; (ii) adjustment of exercise intensity by increasing or decreasing treadmill grade without altering treadmill speed, (iii) inclusion of exercise participants with varying levels of ambulatory function by incorporating body-weight support devices. A disadvantage of treadmill training is that constant supervision is often required. Demonstrated benefits of treadmill training for the people post-stroke period include improved physiologic fitness reserve by increasing $VO2_{peak}$ and decreasing energy expenditure,[29,57,59] increased peak ambulatory workload capacity,[29,57,59] enhanced functional mobility,[57,59] improved glucose tolerance,[39,46] and reduced insulin resistance.[46] Evidence supports the effectiveness of *body-weight* *support treadmill training* post-stroke.[24,33,57,198,60] *Underwater treadmill training* has been reported significantly improve peak cardiorespiratory responses compared to land treadmill training in people in the subacute phase of stroke recovery.[163]

Cycle ergometry can be used by a wide range of individuals post-stroke because it accommodates those who are non-ambulatory.[22] Cycle ergometry provides trunk stability and support for those with poor postural control, making it advantageous for individuals in the early stages of recovery after stroke.[22,104] Cardiorespiratory fitness post-stroke has been increased using cycle ergometry,[22,27,199,200,201] cycle ergometry incorporating lower limb weights,[64] and cycling with biofeedback.[202]

Overground walking Preliminary evidence suggests that metabolic stress of overground walking during the subacute post-stroke period may be inadequate to achieve the minimum requirements for aerobic training.[203] Nevertheless, another study demonstrated that combining walking and resistance training can reduce central arterial stiffness in individuals with chronic post stroke hemiparesis.[51] An exercise trial by Danks et al.[204] found that fast walking training combined with step activity monitoring showed greater improvements in 6MWT than fast walking alone. Repetitive sit-to-stand exercises, marching on the spot while holding a chair, or side stepping can increase the heart rate response of individuals post-stroke whose mobility is limited by balance impairments.[127]

Robotic-assisted gait training has shown to improve VO_{2peak},[205,206] arterial stiffness,[49] and walking capacity,[207,208] as well as reduce energy costs of walking.[209] However, van Nunen et al.[210] reported that their cohort of people post-stroke were unable to meet minimum training intensity levels of 30% HRR for aerobic training.

Best Practice Recommendation 2.6

For long should an aerobic training program be conducted?

A minimum of 8 weeks of aerobic exercise is recommended to achieve a clinically meaningful training effect. However, physical activity should be sustained indefinitely to maintain health benefits.

Level of evidence: B (Several RCTs have demonstrated effective application of aerobic exercise interventions after stroke of ≥8 weeks duration. However, the level of evidence was downgraded due to lack of stroke trials that directly compared different program durations.)

Rationale

The minimum length of time to make the long-term physiological and behavioral adaptations to exercise for improved cardiorespiratory fitness varies from person to person. In general, a period of 8 weeks of aerobic exercise is considered the minimum time needed for these adaptive responses to occur. However, it has long been recognized that benefits of training decline significantly without ongoing participation in physical activity.[211] Consequently, a fundamental objective of a structured exercise program is to elicit changes in participants' attitudes and behaviors regarding habitual physical activity.[185] The ultimate goal is to engage individuals post-stroke in long-term physical activity as part of their daily lives.

System Implications

Access to aerobic exercise programs of at least 8 weeks in duration

Performance Measures

- Percentage of participants who completed an aerobic exercise program of adequate duration

Measurement Notes

Data gathering regarding duration of aerobic exercise sessions requires a chart review or consistent use of reliable workload measurement tools.

Summary of the Evidence

Although the most effective duration of formal aerobic training programs for individuals post-stroke remains to be determined,[113,186] the available literature suggests a minimum of 8 weeks is required. A wide range of program durations was found in the training studies reviewed: 2 weeks,[22,33,34], 4 weeks,[60] 8 weeks,[24,26-28,65,212] 10 weeks,[18] 12 weeks,[19,23] 19 weeks,[50] and 6 months.[20,29,57,59,189] In an overview of exercise studies, Ivey et al.[113] noted that program durations ranging from 8 weeks to 6 months were sufficient to improve cardiorespiratory fitness and function in stroke survivors. Further, because a plateau in VO_{2peak} gains was not achieved over a 6-month period and fitness gains were evenly distributed over the initial and final three month periods, the authors postulated that program durations longer than six months may produce even more benefits.[113]

Data are lacking regarding the sustainability of exercise benefits after stroke. In 2 training RCTs, VO_{2peak} values of the exercise group at 12-month follow-up exceeded baseline values.[198,86] However, given that exercise-mediated cardiopulmonary and metabolic improvements are lost after 4 to 6 weeks of detraining,[213] it is critical to encourage on-going engagement in physical activity.

Best Practice Recommendation 2.7

How frequently should aerobic training sessions be conducted?

Structured aerobic exercise should be conducted a minimum of 3 days/week. On the other days of the week, participants are encouraged to engage in lighter forms of physical activity.

Level of evidence: B (Several RCTs have demonstrated effective application of post-stroke aerobic exercise interventions conducted ≥3 days/week, which is consistent with the evidence from other adult populations. However, the level of evidence was downgraded due to lack of stroke trials that directly compared different frequencies of exercise sessions.)

Rationale

Although recommendations vary, participation in aerobic exercise most days of the week is advised to maintain or improve cardiorespiratory fitness. The ACSM[128] endorsed engaging individuals post-stroke in aerobic exercise 3-5 days/week, whereas Billinger and colleagues[172] recommended ≥3 days/week. In a meta-analysis of 9 post-stroke training studies, Pang et al.[30] reported that the frequencies of exercise sessions were consistent with these recommendations.[17] Evidence is emerging of the benefits of supplementing an exercise program with non-structured physical activity on non-exercise days. Thus, for optimal gains in cardiorespiratory fitness, lighter physical activity, such as brisk walking, should be encouraged on days when the person is not participating in structured aerobic exercise sessions.

Benefits derived from aerobic training are dose dependent, with dose determined by the interaction of frequency, duration, and intensity (**Box 2.7**). It is the total volume of exercise that is important for attaining and maintaining cardiorespiratory fitness; various combinations of frequency, duration, and intensity of aerobic exercise may be used in stroke rehabilitation to achieve the same endpoint.

System Implications

Access to aerobic exercise interventions at least three times per week

Performance Indicators

- Percentage of participants who completed an aerobic exercise program of adequate frequency

Measurement Notes

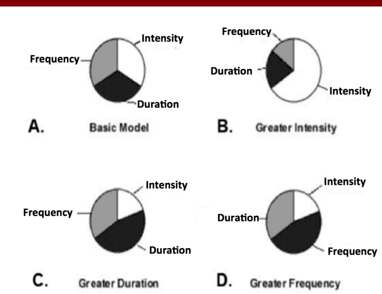
Data gathering regarding frequency of aerobic exercise sessions requires a performance audit, a chart review, or consistent use of reliable workload measurement tools.

Summary of the Evidence

Optimal frequency of aerobic training to improve health and function has not been determined specifically for the stroke population.[186,214] In the post-stroke exercise studies reviewed, 3 days/week was the most commonly used frequency,[20-22,25,26,28,29,57] with frequencies in other studies ranging from 2 - 6 days/week.[19,23,24,27,31,33,34,65,212,60]

Box 2.7 Interaction of frequency, duration, and intensity of aerobic exercise sessions

Frequency of aerobic training sessions cannot be determined without taking into account session and intensity — the total volume of exercise is important. The interaction of intensity, duration, and frequency is illustrated in this diagram.[215] A. Equal frequency, intensity, and duration of exercise; B. Greater intensity, with shorter duration and less frequency of exercise; C. Greater duration and less frequency and intensity; D. Greater frequency, shorter duration, and less intensity.



Best Practice Recommendation 2.8

How long should each aerobic training session last?

Aerobic exercise sessions of ≥20 minutes are recommended, depending on exercise frequency and intensity. Warm-up and cool-down periods of 3-5 minutes are also advised. A gradual progression in the duration may be required, starting with bouts of 5 minutes or less and alternating intervals of rest or lower-intensity exercise.

Level of evidence: B (Several RCTs have demonstrated effective application of aerobic exercise sessions of >20 minutes for the stroke population, in keeping with exercise guidelines for other adult populations. However, the level of evidence was downgraded due to lack of stroke trials that directly compared different durations of exercise sessions.)

Rationale

It is generally accepted that most individuals can achieve their fitness goals by exercising >20 minutes, excluding warm up and cool down; thus 26-30 minutes is required (i.e., 3-5 minutes of warm up and 3-5 minutes of cool down). For very deconditioned individuals, exercise may be delivered in "bouts" of five minutes or less, with rest periods or lower-intensity activity between bouts.

System Implications

Access to aerobic exercise sessions of ≥20 minutes in duration.

Performance Measures

- Percentage of participants who completed an aerobic exercise program of adequate duration

Measurement Notes

Data gathering regarding duration of aerobic exercise sessions requires a performance audit, chart review or consistent use of reliable workload measurement tools.

Summary of the Evidence

As with exercise frequency, evidence on duration of aerobic exercise sessions specifically for the stroke population is lacking.[186] For cardiac populations, the ACSM[17] recommends discontinuous bouts of mobilization of 3-5 minutes for inpatient cardiac rehabilitation and 20-60 minutes of continuous or intermittent aerobic activity per session for outpatient programs. The Cochrane Review by Saunders et al.[216] reported that exercise durations greater than 20 minutes were sufficient to achieve benefits for stroke survivors. Recommended session duration varies from 30 minutes[132] to 20-60 minutes.[128,172] Short 5-10 minutes bouts of aerobic exercise may be better tolerated by stroke survivors who are severely deconditioned or have substantial motor impairments.[59]

In the post-stroke training studies reviewed, duration of aerobic training sessions ranged from 10-20 minutes,[18,33,34] 30 minutes,[22] 40 minutes,[29,57] and 60 minutes.[23,26,28] Studies have also progressed the session duration over time to achieve a total time of 15-60 minutes of aerobic exercise by the end of the intervention period.[19-21,24,59,65,113] In a training study by Macko et al.,[59] the initial session duration involved 2-3 minutes of treadmill walking for those participants unable to walk continuously for long periods of time, progressing by five minutes every other week to achieve a total of 45 minutes by the third month of training.

Best Practice Recommendation 2.9

What intensity of aerobic exercise should be used?

Intensity of aerobic exercise must be determined on an individual basis, depending on response to the exercise stress test, health status (neurologic status, cardiac, and other co-morbidities), and planned exercise frequency and duration. Percentage of heart rate reserve (HRR) is often used to establish the target training intensity. Other markers of intensity, such as percentage of maximal heart rate (% HR_{max}) and rating of perceived exertion (RPE), can be used, particularly when heart rate is compromised by medication.

Light intensity: <40% HRR; <64% HR_{max}; RPE_{0-10} <4 or RPE_{6-20} <12
Moderate intensity: 40-60% HRR; 64-76% HR_{max}; RPE_{0-10} 4-5 or RPE_{6-20} 12-13
Vigorous exercise: >60% HRR; >76% HR_{max}; RPE_{0-10} $\geq$6 or RPE_{6-20} $\geq$14

Level of evidence: B (Several RCTs have demonstrated safe and effective application of aerobic exercise interventions using intensities consistent with those recommended above. However, the level of evidence was downgraded due to lack of stroke trials that directly compared different intensities of exercise sessions.)

Rationale

Intensity of exercise is of foremost concern in exercise prescription because it dictates the level of metabolic stress to which a participant is exposed, safeguards against adverse responses to inappropriately stressful exercise, and is the most critical factor in ensuring an adequate dosage to elicit a training effect. In general, higher intensities elicit greater improvements in cardiopulmonary fitness and insulin sensitivity and greater reductions in vascular risk factors.[217] However, safety and feasibility of attaining a particular training zone need to be taken into account when determining an appropriate exercise intensity for an individual post-stroke. In addition, the interactions of intensity with frequency and duration of aerobic training are important to consider.

System Implications

- Education of health professionals involved in aerobic exercise interventions for individuals post-stroke regarding prescription of exercise intensity
- Access to equipment to monitor heart rate and blood pressure during aerobic exercise (heart rate monitors, sphygmomanometers)

Performance Measures

- Percentage of individuals involved in aerobic exercise that have exercise intensity appropriately established, monitored, and progressed
- Frequency of adverse events

Measurement Notes

Data gathering regarding intensity of aerobic exercise sessions requires a performance audit or chart review.

Summary of the Evidence

The intensity of an aerobic training program depends on baseline fitness level, neurologic and cardiac status, presence of co-morbidities, and goals of the program. ACSM recommended use of the classification of training intensity outlined in Recommendation 2.9[135] and suggested that inactive individuals "start low and go slow" (which would include most people post-stroke).[17] Heart rate is typically used to establish and monitor training intensities. β-blocker medication depresses the heart's response to exercise, posing challenges when prescribing exercise intensity based on predicted rather than measured heart rate-dependent parameters. Also, because of the chronically irregular ventricular rate in the presence of atrial fibrillation, age-predicted HR_{max} is not valid for people with this arrhythmia.[128] **RPE** is a recognized proxy measure of exercise intensity. However, given that substantial inter-individual RPE variability has been documented for people in the subacute stage of stroke recovery during higher intensity exercise,[218] the target RPE should be set for each individual.[185] Pictorial versions of RPE are helpful for people with aphasia (**Box 2.9**). Another proxy measure, the Talk Test, indicates that the individual should be able to talk while exercising, but if the individual can sing, the intensity should be increased; conversely, if the individual cannot talk, the intensity should be decreased. Foster et al.[219] confirmed that the exercise intensity at the ventilatory threshold coincided with the last intensity at which a subject could comfortably speak. With the Count Talk Test the percentage of resting count (i.e., how high a person at rest can count aloud without taking a second breath) achieved during exercise aligned with percentage of HRR, VO_2 reserve, and RPE.[220] A Count Talk Test using 50% of the resting count was found to be strongly correlated with percentage of HRR corresponding to moderate-intensity exercise.[220] **Table 2.9** summarizes relationships among RPE, Talk Test, and physiological measures of intensity, based primarily on data from non-disabled populations.

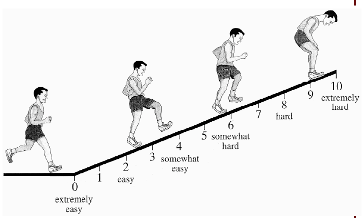
The most effective and safest intensities of aerobic exercise for stroke survivors have not been established.[180,186] For cardiac populations, the ACSM[17] recommends intensities of (i) 40% to 80% of HRR, (ii) RPE_{6-20} of 11-15 or RPE_{0-10} of 4-6, or (iii) heart rate below the determined ischemic threshold for the participant. The ACSM recommends intensities of 40% to 70% of HRR if data are available from a recent graded exercise test.[17] However, a meta-analysis concluded that, for very unfit individuals, intensities as low as 30% of HRR can induce a cardiovascular training effect.[136] For the stroke population, Billinger et al.[172] recommended intensities of 40-70% of VO_{2peak} or HRR, 50-80% of HR_{max}, or an RPE6-20 of 11-14. Intensities in the range of 50-80% of HR_{max} have been found to improve aerobic capacity post-stroke when combined with appropriate frequency and duration.[30]

Several post-stroke training studies used exercise intensities consistent with ACSM recommendations.[18,113,214] Teixeira-Salmela et al.[18] trained individuals in the chronic post-stroke period for 10 weeks using graded walking plus stepping or cycling at a target HR of 70% of baseline HR_{max}. A 6-month treadmill training protocol gradually progressed exercise intensity from an initial level of 40-50% of HRR for 10-20 minutes to a target aerobic intensity of 60-70% of HRR for 40 minutes.[46,114] In a 14-week exercise trial by Rimmer and colleagues,[21] a "moderate-intensity, shorter-duration" group initiated their 30-minute sessions at 40% of HRR and progressed the intensity by 10% every 4 weeks, whereas a "low-intensity, longer-duration" group maintained an intensity of <50% of HRR and increased exercise time from 30-45 to 60 minutes in 4-week increments. Dose-dependent effects on blood pressure and total cholesterol were noted, with better results attained in the moderate intensity, shorter duration group than in the low intensity, longer duration group.[21] Other investigators used more arbitrary indicators of exercise intensity, including cycle ergometer work rate,[19] participant preference,[20] exercise duration,[20,23,27] supervising therapist's determination,[33,34] and peak power output from maximal exercise test.[104]

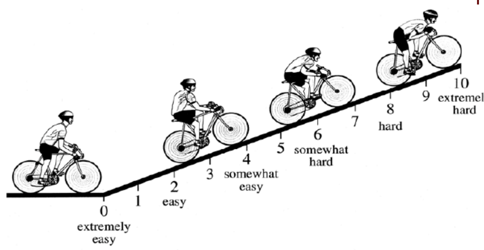
Mounting evidence supports the proposition that higher training intensities are more effective than moderate or low intensities in increasing aerobic capacity, walking speed and endurance in individuals post-stroke.[60,221,222,102,223,224,225] In a treadmill study by Ivey et al.,[224] participants working at intensities of 80% HRR demonstrated increases of 34% in VO_{2peak}. *High intensity interval training* (HIIT), which involves high-intensity exercise interspersed with light-intensity recovery periods, has been shown to induce cardiovascular, functional and neuroplastic improvements in people who are in subacute or chronic stages of stroke.[221,226,227] One advantage of HIIT is the reduction in time required for training (e.g., Boyne et al.[221] reported 58% less time than moderate intensity continuous exercise). However, HIIT requires careful screening for orthopedic and cardiovascular conditions, including exercise stress testing.[221,228] Further, optimal HIIT parameters remain unknown.[223] Boyne et al.[221] outlined 3 types of HIIT protocols: i) Short-interval: short high intensity bursts usually lasting 15-30 seconds at 100-120% VO_{2peak} with a 1:1 recovery time, ii) Low-volume: small bursts of the highest neuromuscular intensity possible (10-30 seconds, up to 60 seconds) followed by a small burst of active recovery (1:4 or 1:12), iii) Long-interval: high intensity bursts lasting 3-4 minutes at submaximal workload of 80-90% VO_{2peak} with 1:1 or 4:3 of active recovery. Low-volume training may be most appropriate for individuals with subacute stroke because it provides the greatest amount of time for recovery and more repetitive mental practice.[221]

Box 2.9 Pictorial versions of RPE

OMNI-Walk RPE scale$_{0-10}$[229]



OMNI-Cycle RPE scale$_{0-10}$[230]



Facial pictorial rating of RPE$_{0-10}$

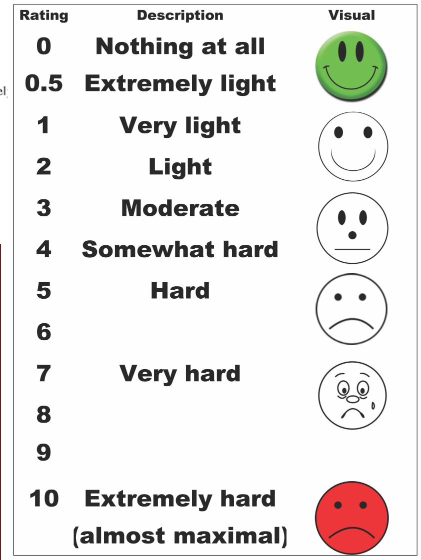


Table 2.9 Approximate relationships among indicators of exercise intensity based on data mainly from studies involving non-disabled individuals. Adapted from[17,135]

Exercise Intensity			Clinical Indicators of Exercise Intensity				
			RPE Scales				Talk Test
Description	**%HRR**	**%HRmax**	**6-20**	**Description**	**0-10**	**Description**	**Description**
Very Light	<30	<57	6		0	Nothing at all	Can sing and converse with no effort
			7	Very, very light	.5	Very, very light	
			8				
Light	30 - <40	57-63	9	Very light	1	Very Light	Can converse with almost no effort
			10				
			11	Fairly light	2	Light	
Moderate	40 - <60	64-76	12		3	Moderate	Can converse comfortably with little effort
			13		4	Somewhat hard	
Vigorous	60 - 89	77-95	14	Somewhat hard	5	Hard	Can converse with some effort
			15	Hard			
			16		6		
			17	Very hard	7	Very hard	Converses with quite a bit of effort
Near maximal or maximal	≥90	≥96	18		8		Can conserve with quite a bit of effort and must stop talking to catch breath
			19	Very, very hard	9		Converses with maximum effort
			20		10	Very, very hard	Unable to converse

Best Practice Recommendation 2.10

What should be monitored during aerobic exercise training?

On-going observation of the general response to exercise, frequent heart rate monitoring, and periodic blood pressure and rating of perceived exertion monitoring are recommended for safety purposes and assurance that the participant is exercising at the planned intensity.

Level of evidence: A (Monitoring protocols used in RCTs on aerobic exercise post-stroke have involved monitoring of heart rate, blood pressure and RPE, consistent with clinical guidelines.)

Rationale

Careful monitoring of heart rate, blood pressure and RPE (or the Talk Test) are critical to ensure safety and optimize effectiveness of aerobic exercise training.

System Implications

- Availability of monitoring equipment (heart rate monitor, sphygmomanometer, RPE chart)

Performance Measures

- Percentage of intervention records that document monitoring data (heart rate, blood pressure, RPE)

Measurement Notes

Performance measurement could be achieved through audits of rehabilitation records and community program records.

Summary of the Evidence

The current discrepancy between research trials and clinical practice regarding the approach to monitoring aerobic exercise programs warrants further investigation. In the majority of aerobic exercise intervention trials reviewed, heart rate, blood pressure and RPE were typically monitored along with others signs of stress or symptoms of cardiovascular or orthopedic adverse responses. However, information is lacking regarding the frequency of monitoring. Boyne et al.[221] discontinued training if SBP or DBP levels exceeded 200 mmHg and 110 mmHg, respectively, or if heart rate was greater than 160 beats/minute. Ivey and colleagues[221] reported that on rare occasions when a participant's response was negatively affected by concerns such as dehydration exercise was temporarily suspended or discontinued, depending on response to rest and hydration.

Compared to research studies, current monitoring practices during aerobic training in stroke rehabilitation are more questionable. In an observational, longitudinal study, monitoring of heart rate and blood pressure during therapy sessions was rarely observed.[174] In recent parallel surveys of American and Canadian physical therapists, 'general response to exercise' was the most common monitoring strategy, used by 94% and 81% by American and Canadian respondents, respectively.[137,138] RPE was used by 64% and 69%, respectively; manual heart rate, 51% versus 43%; heart rate with a device, 75% versus 23%; and blood pressure, 76% versus 25%.[137,138] The percentage of respondents who monitored oxygen saturation was similar to or higher than the percentage monitoring blood pressure – 76% of American respondents[137] and 64% of Canadian respondents.[138] This finding is surprising given that, apart from people post-stroke who also have chronic obstructive pulmonary disease, respiratory compromise is not a common limiting factor during functional activities.[231,232] ASCM recommends use of oximetry in the initial training session if there is concern regarding the possibility of exercise-induced oxyhemoglobin desaturation.[17]

Best Practice Recommendation 2.11

How should aerobic exercise be progressed during a training program?

Aerobic exercise should be progressed on an individual basis, with gradual progression of frequency, duration and intensity to minimize muscle soreness, fatigue, and injury. Duration should be increased by 5-10 minutes every 1-2 weeks for the first 4-6 weeks and intensity by 5-10% of heart rate reserve every 1-4 weeks, depending on fitness, health status, training responses, and exercise goals. Changes in blood pressure, heart rate, and rating of perceived exertion in response to the increased exercise dose should be monitored.

Level of evidence: B (In several stroke RCTs the training program was progressed in accordance with the above recommendation. However, the level of evidence was downgraded due to lack of stroke trials that directly compared different protocols for progressing aerobic exercise.)

Rationale

As with any exercise intervention, gradual progression of aerobic training is a fundamental component of a safe and effective program. Progression is necessary because the cardiorespiratory system must undergo a continuous challenge in order to optimize fitness gains. Gradual progression of session frequency, duration and intensity provides the metabolic stress needed to induce a training effect without jeopardizing participant safety.[17]

System Implications

- Education of health professionals involved in prescribing and progressing aerobic exercise interventions for individuals post-stroke
- Access to equipment to monitor heart rate and blood pressure during aerobic exercise (heart rate monitors, sphygmomanometers)

Performance Measures

- Percentage of intervention records that document the plan for, and adherence to, progression of the training program

Summary of the Evidence

Research regarding the most effective progression regimen for aerobic training post-stroke is lacking. Often progression involves periodic increases in exercise duration and/or intensity.

Exercise duration ACSM recommends that exercise training sessions for inactive individuals be progressed by increasing duration 5-10 minutes every 1-2 weeks for the first 4-6 weeks or as tolerated.[17] By way of example, in an RCT by Gordon et al,[53] training began with 15 minutes of overground walking and progressed in 5-minute increments each week until 30-minute sessions were reached. Results showed improved quality of life and 6-minute walk test distance and reduced resting heart rate.[53] In another RCT by Jin et al.[199] 10-20 minutes of cycle ergometry was performed initially, with the duration progressed in 5-minute increments every 2 weeks until 40-minute sessions were achieved. The protocol resulted in improvements in VO_{2peak} and bilateral quadriceps strength.[199] The progression protocol of a higher intensity treadmill training study involved 5-minute increases in duration every 2 weeks until a target intensity of 80-85% HRR was reached.[86,224]

Exercise intensity Gradual increases in the percentage of HRR can be achieved during training sessions by systematically manipulating parameters such as speed, revolutions per minute, incline, and extent of balance support.[181] In most of post-stroke training studies reviewed, aerobic training protocols began at 40-50% HRR and progressed as tolerated to intensities up to 85% HRR. Progression of HRR ranged from <u>5%</u>[61,65, 171,199,212] to <u>10%</u> increases,[171,189,127] <u>once weekly</u>,[61,65,212,171] every <u>2 weeks</u>,[199] or every <u>4 weeks</u>.[50,189,127]

Best Practice Recommendation 2.12

What clinical outcome measures should be used to monitor the effects of aerobic training?

Outcomes aligned with participant-oriented goals and anticipated benefits of the aerobic exercise program should be assessed periodically to monitor change over time, progress intervention, and transition to other settings or physical activities. The assessment should include measures of cardiovascular endurance/functional capacity (e.g., 6-Minute Walk Test, Shuttle Walk Test, heart rate at a fixed submaximal workload, walking speed, daily step counts), cardiovascular health (e.g., blood pressure, blood lipids, fasting plasma glucose, waist circumference, medication adherence, tobacco use), and other relevant domains (e.g., goal attainment, cognition, emotional well-being, exercise self-efficacy, quality of sleep, quality of life).

Level of evidence: B (Several post-stroke exercise trials have demonstrated effective application of a broad range of outcome measures. However, level of evidence was downgraded because the minimum set of outcome measures has not been ascertained.)

Rationale

Given the numerous potential benefits of aerobic exercise interventions (see Box 1.1), outcome assessment should be aligned with anticipated outcomes. The most likely benefits are often those most closely associated with the intervention provided (in the case of aerobic interventions, these benefits include improved exercise capacity, fatigue levels, and vascular risk profile). More remote benefits include improved mobility, cognition, emotional wellbeing, sleep quality, and quality of life.

System Implications

- Education/training of health professionals about appropriate outcome assessment and documentation.
- Access to equipment for assessment and documentation.

Performance Measures

- Percentage of standardized stroke rehabilitation assessments that incorporate outcome assessment related to aerobic exercise interventions.
- Percentage of individuals engaged in aerobic exercise after stroke or TIA for whom outcome assessment related to aerobic exercise interventions has been administered.

Measurement Notes

Data gathering regarding outcome assessments requires a chart review.

Summary of the Evidence

Evidence related to tests of exercise capacity is discussed under Recommendation 1.5. A systematic review and meta-analysis revealed a low correlation between walking speed and VO_{2peak} (r = .42) and a moderate correlation between the 6MWT and VO_{2peak} (r = .52).[233] The authors reasoned that several factors (e.g., age, balance, stroke severity, lower extremity strength) mediate relationships between exercise capacity and functional capacity.[233] In keeping with that interpretation, Stookey[233] reported a stronger correlation between the 6MWT and the Short Physical Performance Battery (r = .76) than between VO_{2peak} and the Short Physical Performance Battery (r = .52).

Accelerometers, including StepWatch[234,235] and Fitbit[101,236,236] devices, yield valid and reliable data regarding physical activity of individuals post-stroke.[237,238,239,240] A published clinical guideline recommended 3 days of monitoring of daily step counts for community-dwelling stroke survivors.[241] Monitoring of *cardiovascular risk* is particularly important in the prevention of further vascular events.[242] The cardiac risk score[243] was used in a pilot RCT to evaluate effectiveness of adapted cardiac rehabilitation on risk factor reduction of community-dwelling stroke survivors.[85] A measure of *exercise self-efficacy*, the Participation Strategies Self-efficacy Scale, is reliable for people with mild to moderate stroke.[244]

Best Practice Recommendation 2.13

What strategies can be used to encourage long-term participant engagement in aerobic training after stroke or TIA?

An individualized plan, endorsed by the health care team, should be implemented to gradually transition from structured, clinical aerobic training to less structured, more self-directed physical activity at home or in the community. Multiple strategies should be used to deal with specific barriers related to health care providers, the environment, and the participant.

Level of evidence: B (Evidence is emerging from recent RCTs regarding effective strategies to engage people post-stroke in aerobic exercise.)

Rationale

Evidence supporting the benefits of aerobic exercise post-stroke on cardiovascular and functional health is increasing, and, at the same time, interventions to facilitate achievement of these benefits are emerging.[245] On the other hand, preliminary evidence suggests that the benefits of aerobic exercise are not sustained in the long term because participants either stop participating in such programs or decrease their level of engagement.[246]

Evidence-informed strategies, such as motivational interviewing,[247] that are consistent with theories of behavioral change (e.g., Transtheoretical Model, Social Cognitive Theory, Theory of Reasoned Action, Theory of Planned Behavior, Health Belief Model, Protection Motivation Theory, Self-Determination Theory) serve as useful frameworks for development of new approaches to aerobic exercise interventions that facilitate long-term engagement.[248] Ultimately, the exercise program must be tailored to the level of impairment and social and environmental contexts of the stroke survivor.

System Implications

- Education of health professionals regarding theories of behavioral change and motivational strategies.
- Support for transportation, well-maintained facilities, and equipment.

Performance Measures

Percentage of individuals who sustain participation in prescribed aerobic exercise interventions.

Measurement Notes

Data gathering regarding participant engagement via follow-up surveys.

Summary of the Evidence

Numerous psychological, cognitive, and emotional factors are known to influence engagement in physical activity (e.g., self-efficacy, attitude, competence, intention, motivation, perceived value of exercise benefits, readiness to change) in non-stroke populations.[249] According to Bandura's social cognitive theory, core individual determinants of behaviour change include self-efficacy (i.e., belief that one has control over change in a particular behaviour such as exercising), knowledge of lifestyle habits, outcome expectations (expected benefits versus costs of performing a particular behaviour), goal setting and strategies for goal attainment, and perceived facilitators and barriers to goal attainment.[250]

Morris and Williams[251] noted that in addition to individual characteristics, social and cultural influences and environmental features (e.g., access to facilities, transportation), affect the level of engagement in exercise and physical activity in populations with physical disabilities. Investigation has also begun regarding the influence of the design of the physical environment on physical activity of people with neurological conditions.[252] The complexity of variables confounds identification of effective personal strategies, particularly with reference to people post-stroke. For example, age post-stroke has been reported to be inversely related to level of adherence to aerobic training,[253] and cost of the exercise program has been found to be the most commonly perceived barrier to exercise of people in the chronic post-stroke period.[253] Other barriers have been identified, including lack of awareness of a fitness center, lack of transportation to a fitness, and inadequate of knowledge of how to exercise,[254] as well as mobility problems, other health concerns, cognitive and mental health issues and lack of support from family.[255,256] A systematic review of patients' experiences with stroke rehabilitation identified themes of disempowerment (loss of independence and autonomy), boredom, and frustration.[239] Participants perceived that the purposes of exercises were not adequately communicated and they wanted more meaningful tasks to practice, opportunities to perform exercises outside formal therapy, and more access to recreational activities.[239]

Exercise preference is important to consider in developing a *personalized exercise program*. Distinct differences have been reported between people post-stroke and non-disabled, age-matched individuals – relative to their non-disabled counterparts, stroke survivors preferred to exercise with others of similar age at a gym or fitness centre using a structured exercise format beginning with a demonstration of each exercise.[257] The Exercise Preference Inventory-13 is a 13-item questionnaire developed to assess exercise preferences and identify barriers (e.g., anxiety, depression, fatigue and disability) of the stroke population.[258]

Qualitative studies examining participation of stroke survivors in exercise programs have identified *self-efficacy* as an important psychological predictor of level of engagement.[188,259,260] People involved in stroke rehabilitation have expressed concerns about lack of exercise self-efficacy in terms of low confidence in their ability to overcome challenges to exercise and lack of information on how to perform aerobic exercise.[255] French and colleagues[261] provided evidence that self-efficacy post-stroke mediates the relationships between performance-based measures of walking and real-world walking (daily step counts) and participation (Stroke Impact Scale – Participation Subscale). General interventions to enhance self-efficacy and exercise participation include counseling and information,[262] behavioral change techniques, social support and education,[263] and motivational counseling through videotapes.[264] There is some evidence specific to the stroke population to support the use of self-management programs,[265,266] individualized tailored counseling,[267] behavioural change techniques (e.g., goal setting, barrier identification, self-monitoring)[268] and accelerometer-based feedback.[269] Consequently, a fundamental objective of a structured exercise program is to elicit changes in participants' attitudes and behaviors regarding habitual physical activity.[185] Given that exercise-mediated cardiopulmonary and metabolic improvements are lost after 4 to 6 weeks of detraining,[213] it is critical to encourage on-going commitment to physical activity.

Box 2.13 Barriers to participant engagement in aerobic training post-stroke and strategies to overcome these barriers

Category	Specific Barriers	Strategies to Overcome Barriers
Health providers	Lack of belief in role/benefits of exercise	• Continuing professional education • Team building
	Lack of knowledge of theories of behavioral change, motivational strategies	• Professional education • Provider toolkit
	Lack of qualified and enthusiastic health professional staff	• Professional/continuing professional education • Support of health care administrators
Environment	Inadequate administrator support	• Education of health care decision makers re benefits
	Lack of availability of exercise testing	• Share resources with cardiac rehabilitation personnel
	Lack of continuity of programs along the continuum of care	• Communication among providers at transitions in the health care continuum • Government policies to support for community-based physical activity programs
	Lack of social support for participant to attend	• Buddy system • Education of families and caregivers • Regular and convenient scheduling of program
	Lack of employer support for participant to attend	• Education of employers • Encouragement of flex time and exercise facilities at workplace • Government incentives for employers
	Lack of availability of nearby facilities (i.e., within a 30-minute radius)	• Polyvascular management (e.g., combining stroke and cardiac rehabilitation; combining medication and exercise) • Use of existing community and clinical facilities • Telehealth
	Lack of funding for programs	• Government policies to provide funding to cover facility/program fees (particularly low-income families) • Development of low-cost options such as community-based walking programs
	Lack of transportation	• Government policies for accessible transportation • Car pooling • Volunteer drivers
Participants	Reduced self-efficacy (i.e., external locus of control, feeling of a lack of autonomy) Lack of motivation	• Telephone reminders regarding exercising • Buddy or mentor system • Participant-oriented goal setting • Self-management programs • Individualized tailored counseling • Motivational interviewing
	Lack of readiness to participate	• Assessment of state of readiness • Program tailored to different stages of readiness
	Lack of belief in role/benefits of exercise (e.g., sedentary premorbid lifestyle, cultural beliefs)	• Participant education • Self-monitoring of exercise progress (e.g., health passports, exercise logs, step counters) • Monitoring and discussion of beneficial effects of exercise (e.g., reduced blood pressure, decreased blood glucose, reduced fatigability)
	Inability to communicate (expressive aphasia)	• Provision of aphasia-friendly educational material
	Depression and anxiety	• Screening for depression and anxiety • Referral system
	Fear of exercise (e.g., falling, second stroke)	• Education on mitigating risk, selecting exercise mode, self-monitoring of adverse events
	Excessive fatigue	• Gradual progression of exercise intensity
	Lack of enjoyment of exercise	• Group programs with emphasis on socialization and fun • Positive feedback • Variety in program to reduce boredom • Use of age-appropriate music • Hydration and refreshments during and after exercising • Incorporation of physical activity into daily routine (e.g., walking, stair climbing, active leisure, recreation)

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Appendix A: Steps in Development of AEROBICS 2013

Identification of Recommendation Development Process

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Formation of Consensus Panel

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Preparation of Literature Synthesis

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Identification of clinically relevant questions

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Consensus Workshop for Recommendation Development

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Refinement of Recommendations by Working Group

↓

Consensus Panel Review of Revised Recommendations

↓

Incorporation of Consensus Panel Feedback

↓

Review of Revised Recommendations by External Reviewers & Focus Group

↓

Incorporation of External Reviewers & Focus Group Feedback

↓

Review of Revised Recommendations by Consensus Panel

↓

Initial Assignment of Strength of each Recommendation by each Panelist

↓

Revision of those Recommendations with <80% Agreement among Panelists

↓

Final Assignment of Strength of each Recommendation by each Panelist

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Dissemination of Recommendations

Appendix A (cont'd): Steps in Development of AEROBICS 2013

External reviewers and focus group participants	
External Reviewers	
Dina Brooks	Physical Therapist, Professor Department of Physical Therapy, University of Toronto, ON
Pamela Duncan	Physical Therapist, Professor, Department of Neurology and Transitional Outcomes, Wake Forest Baptist Medical. Center, NC
Esmé French	Physical Therapist, Regional Stroke Rehabilitation Specialist, Northwestern Ontario Regional Stroke Network, Thunder Bay, ON
Fred Ivey	Exercise Physiologist, Associate Professor, Neurology, University of Maryland, MD
Michal Katz-Leurer	Physical Therapist, Department of Physical Therapy Faculty of Medicine, Tel Aviv University, Israel
Olive Lennon	Physical Therapist, Lecturer, Royal College of Surgeons, Dublin, Ireland
Alison McDonald	Physical Therapist, Nova Scotia Rehabilitation Centre, Queen Elizabeth II Health Sciences Centre, Halifax, NS
Gillian Mead	Geriatrician, University of Edinburgh, Scotland
Anita Mountain	Physiatrist, Acquired Brain Injury Program, Nova Scotia Rehabilitation Centre Site, Queen Elizabeth II Health Sciences Centre and Lecturer, Dalhousie University
Elliot J. Roth	Physiatrist, Paul B. Magnuson Professor and Chairman, Department of Physical Medicine and Rehabilitation, Northwestern University Fienberg School of Medicine; Medical Director, Brain Injury Medicine and Rehabilitation Program; Director, Stroke Rehabilitation Research and Training Centre; Director, Midwest Regional Traumatic Brain Injury Model System, Rehabilitation Institute of Chicago, Chairman, Rehabilitation Medicine, Northwestern Memorial Hospital, Chicago, IL
Katherine Sullivan	Physical Therapist, Associate Professor of Clinical Physical Therapy, Department of Biokinesiology and Physical Therapy, University of Southern California, CA
Jacqueline Tetro	Senior policy analyst, Knowledge Translation, Canadian Institutes of Health Research
Focus Group Members	
George Croucher	Community-dwelling stroke survivor
Susan Croucher	Caregiver
Brenda Medynski	Community-dwelling stroke survivor
Margaret Perron	Community-dwelling stroke survivor
Dave Sharp	Community-dwelling stroke survivor

Appendix B: Electronic Physical Activity Readiness Medical Examination and Physician Clearance Follow-up

Physical Activity Readiness Medical Examination (revised 2002)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

The PARmed-X is a physical activity-specific checklist to be used by a physician with patients who have had positive responses to the Physical Activity Readiness Questionnaire (PAR-Q). In addition, the Conveyance/Referral Form in the PARmed-X can be used to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. The PAR-Q by itself provides adequate screening for the majority of people. However, some individuals may require a medical evaluation and specific advice (exercise prescription) due to one or more positive responses to the PAR-Q.

Following the participant's evaluation by a physician, a physical activity plan should be devised in consultation with a physical activity professional (CSEP-Certified Personal Trainer™ or CSEP-Certified Exercise Physiologist™). To assist in this, the following instructions are provided:

PAGE 1: • Sections A, B, C, and D should be completed by the participant BEFORE the examination by the physician. The bottom section is to be completed by the examining physician.

PAGES 2 & 3: • A checklist of medical conditions requiring special consideration and management.

PAGE 4: • Physical Activity & Lifestyle Advice for people who do not require specific instructions or prescribed exercise.

• Physical Activity Readiness Conveyance/Referral Form - an optional tear-off tab for the physician to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

This section to be completed by the participant

A PERSONAL INFORMATION:

NAME ______________________

ADDRESS ______________________

____

TELEPHONE ______________________

BIRTHDATE ______________ GENDER ________

MEDICAL No. ______________________

B PAR-Q: Please indicate the PAR-Q questions to which you answered YES

- ❑ Q 1 Heart condition
- ❑ Q 2 Chest pain during activity
- ❑ Q 3 Chest pain at rest
- ❑ Q 4 Loss of balance, dizziness
- ❑ Q 5 Bone or joint problem
- ❑ Q 6 Blood pressure or heart drugs
- ❑ Q 7 Other reason: ______________________

C RISK FACTORS FOR CARDIOVASCULAR DISEASE:

Check all that apply

- ❑ Less than 30 minutes of moderate physical activity most days of the week.
- ❑ Currently smoker (tobacco smoking 1 or more times per week).
- ❑ High blood pressure reported by physician after repeated measurements.
- ❑ High cholesterol level reported by physician.
- ❑ Excessive accumulation of fat around waist.
- ❑ Family history of heart disease.

Please note: *Many of these risk factors are modifiable. Please refer to page 4 and discuss with your physician.*

D PHYSICAL ACTIVITY INTENTIONS:

What physical activity do you intend to do?

____

____

____

This section to be completed by the examining physician

Physical Exam:

Ht	Wt	BP i) /
		BP ii) /

Conditions limiting physical activity:

- ❑ Cardiovascular
- ❑ Respiratory
- ❑ Other
- ❑ Musculoskeletal
- ❑ Abdominal

Tests required:

- ❑ ECG
- ❑ Exercise Test
- ❑ X-Ray
- ❑ Blood
- ❑ Urinalysis
- ❑ Other

Physical Activity Readiness Conveyance/Referral:

Based upon a current review of health status, I recommend:

Further Information:
- ❑ Attached
- ❑ To be forwarded
- ❑ Available on request

- ❑ No physical activity
- ❑ Only a medically-supervised exercise program until further medical clearance
- ❑ Progressive physical activity:
  - ❑ with avoidance of: ______________________
  - ❑ with inclusion of: ______________________
  - ❑ under the supervision of a CSEP-Certified Exercise Physiologist™
- ❑ Unrestricted physical activity–start slowly and build up gradually

Physical Activity Readiness
Medical Examination
(revised 2002)

	Special Prescriptive Conditions	ADVICE
Lung	❑ chronic pulmonary disorders	special relaxation and breathing exercises
	❑ obstructive lung disease ❑ asthma	breath control during endurance exercises to tolerance; avoid polluted air
	❑ exercise-induced bronchospasm	avoid hyperventilation during exercise; avoid extremely cold conditions; warm up adequately; utilize appropriate medication.
Musculoskeletal	❑ low back conditions (pathological, functional)	avoid or minimize exercise that precipitates or exasperates e.g., forced extreme flexion, extension, and violent twisting; correct posture, proper back exercises
	❑ arthritis—acute (infective, rheumatoid; gout)	treatment, plus judicious blend of rest, splinting and gentle movement
	❑ arthritis—subacute	progressive increase of active exercise therapy
	❑ arthritis—chronic (osteoarthritis and above conditions)	maintenance of mobility and strength; non-weightbearing exercises to minimize joint trauma (e.g., cycling, aquatic activity, etc.)
	❑ orthopaedic	highly variable and individualized
	❑ hernia	minimize straining and isometrics; stregthen abdominal muscles
	❑ osteoporosis or low bone density	avoid exercise with high risk for fracture such as push-ups, curl-ups, vertical jump and trunk forward flexion; engage in low-impact weight-bearing activities and resistance training
CNS	❑ convulsive disorder not completely controlled by medication	minimize or avoid exercise in hazardous environments and/or exercising alone (e.g., swimming, mountain climbing, etc.)
	❑ recent concussion	thorough examination if history of two concussions; review for discontinuation of contact sport if three concussions, depending on duration of unconsciousness, retrograde amnesia, persistent headaches, and other objective evidence of cerebral damage
Blood	❑ anemia—severe (< 10 Gm/dl) ❑ electrolyte disturbances	control preferred; exercise as tolerated
Medications	❑ antianginal ❑ antiarrhythmic ❑ antihypertensive ❑ anticonvulsant ❑ beta-blockers ❑ digitalis preparations ❑ diuretics ❑ ganglionic blockers ❑ others	NOTE: consider underlying condition. Potential for: exertional syncope, electrolyte imbalance, bradycardia, dysrhythmias, impaired coordination and reaction time, heat intolerance. May alter resting and exercise ECG's and exercise test performance.
Other	❑ post-exercise syncope	moderate program
	❑ heat intolerance	prolong cool-down with light activities; avoid exercise in extreme heat
	❑ temporary minor illness	postpone until recovered
	❑ cancer	if potential metastases, test by cycle ergometry, consider non-weight bearing exercises; exercise at lower end of prescriptive range (40-65% of heart rate reserve), depending on condition and recent treatment (radiation, chemotherapy); monitor hemoglobin and lymphocyte counts; add dynamic lifting exercise to strengthen muscles, using machines rather than weights.

*Refer to special publications for elaboration as required

The following companion forms are available online: http://www.csep.ca

The **Physical Activity Readiness Questionnaire (PAR-Q)** - a questionnaire for people aged 15-69 to complete before becoming much more physically active.

The **Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for PREGNANCY)** - to be used by physicians with pregnant patients who wish to become more physically active.

For more information, please contact the:

Canadian Society for Exercise Physiology
202 - 185 Somerset St. West
Ottawa, ON K2P 0J2
Tel. 1-877-651-3755 • FAX (613) 234-3565 • Online: www.csep.ca

Note to physical activity professionals...

It is a prudent practice to retain the completed Physical Activity Readiness Conveyance/Referral Form in the participant's file.

Supported by: Public Health Agency of Canada / Agence de la santé publique du Canada

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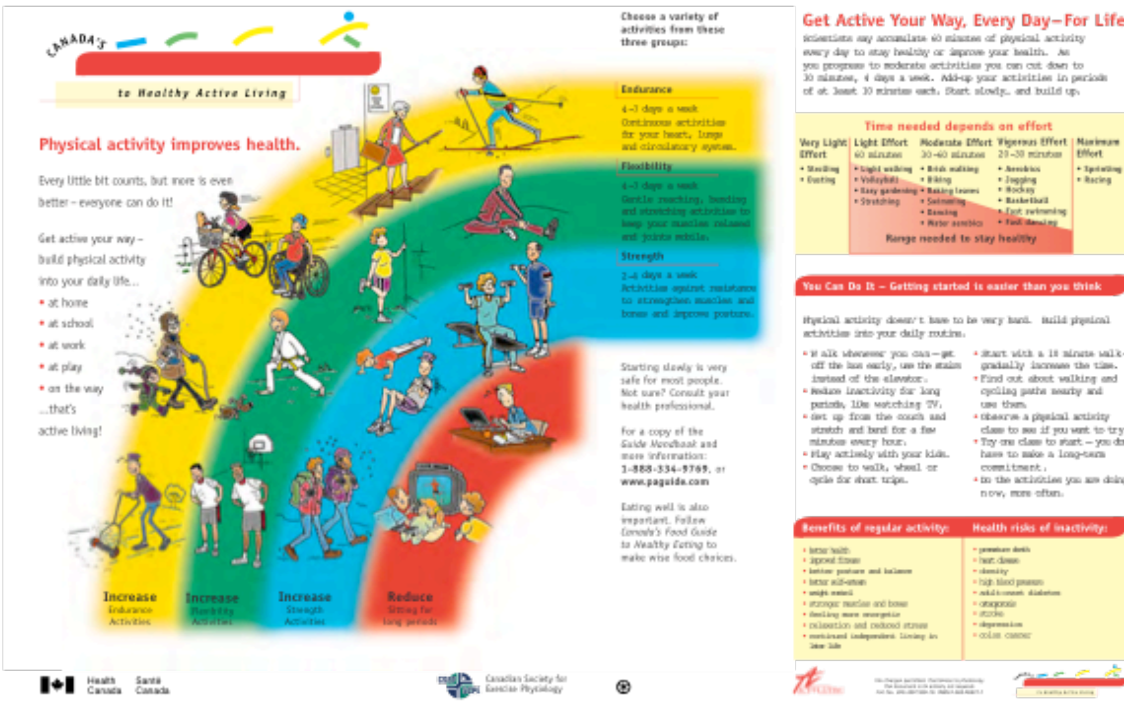
Physical Activity Readiness
Medical Examination
(revised 2002)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION



Source: Canada's Physical Activity Guide to Healthy Active Living, Health Canada, 1998 http://www.hc-sc.gc.ca/hppb/paguide/pdf/guideEng.pdf

PARmed-X Physical Activity Readiness Conveyance/Referral Form

Based upon a current review of the health status of ______________________________, I recommend:

- ❑ No physical activity
- ❑ Only a medically-supervised exercise program until further medical clearance
- ❑ Progressive physical activity
  - ❑ with avoidance of: ______________________________
  - ❑ with inclusion of: ______________________________
  - ❑ under the supervision of a CSEP-Certified Exercise Physiologist™
- ❑ Unrestricted physical activity — start slowly and build up gradually

Further Information:
- ❑ Attached
- ❑ To be forwarded
- ❑ Available on request

Physician/clinic stamp:

______________________________ M.D.

______________________________ 20______
(date)

NOTE: This physical activity clearance is valid for a maximum of six months from the date it is completed and becomes invalid if your medical condition becomes worse.

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